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Northern Shrimp (*Pandalus borealis*) off Baffin Island, Labrador and Northeastern Newfoundland.

Évaluations des stocks de crevette nordique (*Pandalus borealis*) au large de l'île de Baffin, du Labrador et du nord-est de Terre-Neuve.

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ABSTRACT

Northern shrimp (*Pandalus borealis*) assessments were completed for Division 0B, Division 2G, Hopedale + Cartwright Channels and Hawke Channel + Division 3K, which correspond to shrimp fishing areas 2, 4, 5 and 6 respectively. Status of the resource in each area was inferred, in part, by examining trends in commercial catch, effort, catch per unit effort, fishing pattern and size/sex/age composition of the catches. A multispecies research trawl survey that was conducted in 2002 provided information on distribution, abundance, biomass, size/sex composition and age structure of shrimp in Cartwright Channel and Hawke Channel + Div. 3K. These findings were compared with results of previous surveys in these areas.

Catch rates by offshore vessels in Hopedale + Cartwright remained relatively stable at a high level, while those in Hawke + 3K decreased below 2001 values. The research survey in the fall of 2002 showed that abundance and biomass estimates within Hawke +3K and Cartwright Channel decreased slightly, but remain statistically similar to 2001 levels in the respective areas. Catch rates in Div. 2G are being maintained near the long term mean value, while rates in Div. 0B varied at a high level since 1996.

The shrimp resource in Hawke Channel + Div. 3K is currently healthy with the second highest total biomass/ abundances indices in the time series. Female biomass/ abundances are the highest in the time series. Residual female biomass and stronger 1997 and 1998 year classes should buffer the effects of a weak 1996 year class for the next few years. Biomass/ abundance indices within Cartwright Channel have decreased since 2001. It is not clear whether indices developed for Cartwright Channel are indicative of stock status within all of SFA 5. Due to operational problems, the 2001 and 2002 surveys in SFAs 5 and 6 occurred two months later than usual, and may not have covered all of the stock area. Additionally, the 2001 survey was completed, in part, by a new vessel. The relative influences of these factors upon the survey results are unknown. Current status and prospects in Div. 2G are unknown because the lack of a research survey since 1999 precluded evaluation of the spawning stock, the level of exploitation and recruitment. There has never been a research survey into Div. 0B. This creates uncertainty in understanding the current state of stock, distribution, delineation and exploitation level, therefore, prospects in 0B are unknown.

Résumé

Des évaluations des stocks de crevette nordique (*Pandalus borealis*) de la division 0B, de la division 2G, des chenaux Hopedale + Cartwright et du chenal Hawke + division 3K, qui correspondent respectivement aux zones de pêche de la crevette 2, 4, 5 et 6, sont présentées. Nous avons inféré l'état de la ressource dans chaque zone en partie des tendances dans les prises commerciales, l'effort, les prises par unité d'effort, les patrons de pêche et la composition des prises par taille, sexe et âge. Nous avons ensuite utilisé les données d'un relevé polyvalent de recherche au chalut effectué en 2002 pour établir la distribution, l'abondance, la biomasse, la composition par taille et par sexe et la structure par âge de la crevette dans le chenal Cartwright et le chenal Hawke + division 3K, puis nous les avons comparées aux résultats de résultats antérieurs effectués dans ces zones de pêche.

Les taux de capture réalisés par les bateaux hauturiers dans les chenaux Hopedale et Cartwright, sont demeurés élevés et relativement stables, tandis que ceux réalisés dans le chenal Hawke + 3K ont diminué par rapport à 2001. Le relevé de recherche effectué à l'automne 2002 dans le chenal Hawke + 3K et le chenal Cartwright a révélé que l'abondance et l'estimation de la biomasse y ont légèrement diminué, quoiqu'elles demeurent statistiquement semblables aux niveaux observés en 2001. Les taux de capture dans 2G se maintiennent près de la moyenne à long terme, tandis que les taux dans la 0B restent élevés quoiqu'ils varient depuis 1996.

La ressource en crevette dans le chenal Hawke + 3K est actuellement en bon état, comme l'indiquent les indices d'abondance totale et de biomasse, les deuxièmes plus élevés de la série chronologique. La biomasse et l'abondance de femelles viennent au premier rang dans cette série. La biomasse résiduaire de femelles et les abondantes classes d'âge 1997 et 1998 devraient amortir les effets de la faible classe d'âge 1996 au cours des prochaines années. Les indices de biomasse et d'abondance dans le chenal Cartwright ont diminué depuis 2001. Il n'est pas clair si les indices établis pour le chenal Cartwright sont révélateurs de l'état du stock dans toute la zone 5. À cause de problèmes opérationnels, les relevés de 2001 et 2002 dans les zones 5 et 6 ont été effectués deux mois plus tard que d'habitude; il se peut donc que toute la zone du stock n'ait pas été couverte. En outre, le relevé de 2001 a été effectué en partie sur un nouveau navire. L'incidence relative de ces facteurs sur les résultats des relevés est inconnue. Nous ne savons pas quels sont l'état actuel et les perspectives du stock de 2G; des relevés de recherche n'y ayant pas été effectués depuis 1999, il nous a été impossible d'évaluer la biomasse et l'abondance du stock reproducteur, le niveau d'exploitation et le recrutement. Comme un relevé de recherche n'a jamais été effectué dans 0B, nous ne sommes pas en mesure d'établir clairement l'état actuel de ce stock, sa distribution, sa délimitation et le taux d'exploitation, ni ses perspectives.

INTRODUCTION

The Canadian fishery for northern shrimp (*Pandalus borealis*) from southern Davis Strait (Division 0B) to the northeast Newfoundland Shelf (Division 3K) has been regulated within three-year, integrated management plans since 1991.

This research assessment, conducted during May 2003, included four shrimp fishing areas (SFA's): Hawke Channel + NAFO Division 3K (SFA 6), Hopedale + Cartwright Channels (SFA 5), Division 2G (SFA 4) and Division 0B (SFA 2).

MATERIAL AND METHODS

Commercial fishery data

Large vessel (>500 t) Catch Per Unit Effort (CPUE) was calculated by year for each SFA and is used as an indicator of change in the fishable stock over time. Models derived for the present assessment made use of observer datasets because we wanted to account for the usage of windows (escape openings). The usage of windows is captured in the observer dataset but not in the logbooks. Additionally, there is 100% observer coverage of the large vessel fleet. Records indicating more than one trawl and/ or the presence of windows were omitted from these calculations. Raw catch/ effort data for each SFA were standardized by multiple regression, weighted by effort, in an attempt to account for variation due to factors such as year, month, area and vessel. The multiplicative model has the following logarithmic form:

$$Ln(CPUE_{ijkl}) = ln(u) + ln(A_i) + ln(S_j) + ln(V_k) + ln(Y_l) + e_{ijkl}$$

Where: $CPUE_{ijkl}$ is the CPUE for vessel k, fishing in area i in month during year l (k=1,.....,a; j=1,.....,s; i=1,.....,y);
$ln(u)$ is the overall mean ln(CPUE);
A_l is the effect of the l^{th} area;
S_j is the effect of the j^{th} *month;*
V_k is the effect of the k^{th} vessel;
Y_l is the effect of the l^{th} *year;*
e_{ijkl} is the error term assumed to be normally distributed $N(0,\sigma^2/n)$ where n is the number of observations in a cell and σ^2 is the variance.

The standardized CPUE indices are the antilog of the year coefficient. In order to track only experienced fishermen, and reduce the number of estimated parameters, vessels with less than two years of experience were excluded from the analyses. This increased our confidence when interpreting results.

Final models included all significant class variables with the YEAR effect used to track the trend in stock size over time. The difference (or similarity) between the 2002 YEAR parameter estimate and those of previous years was inferred from the output statistics.

Similar models were developed for the small vessel (<=500 t; <100') fleet. However, these models used the logbook dataset, because observers monitor only 10% of small vessel activities.

Logbook and observer catches were plotted using Surfer 8.0 (Golden Software, 2002) . The area fished each year was divided into 10 min.X 10 min. cells, catches were aggregated by cells, aggregated catches were organized into a cumulative percent frequency (cpf). The cpf was used to determine the number of cells accounting for 95% of the catch each year (Swain and Morin, 1996). The plots and quantification of spatial coverage were used in describing changes in fishing patterns and practices that might affect CPUE interpretations.

Carapace lengths of male and female shrimp in the catches were obtained from samples taken by observers on both large and small vessels. Samples were adjusted upward to set, month and year for each SFA to derive a series of annual catch-at-length compositions. Age structure was inferred by identifying prominent year classes (modes) within composite length distributions and tracking their development over time. These samples are considered representative throughout much of the time series. However, the small vessel fleet began harvesting shrimp during 1997. Prior to 2000, it was felt that observer coverage of the small vessel fleet was not sufficient for scientific purposes. Therefore, the 1997 – 1999 commercial length distributions, based on sampling from only large vessels (>500 t), might not be representative of catch at length and age from both fleets.

Research survey data

Shrimp abundance, biomass, maturity and carapace length data have been collected since autumn 1995, as part of the Canadian multispecies surveys conducted using the CCG Wilfred Templeman, CCG Alfred Needler and CCG Teleost. Fishing sets of 15 minute duration and a towing speed of 3 knots were randomly allocated within strata, to depths of 1500 m. The surveys have a target of one sample per 350 sq. Nmi, with a minimum of two samples per stratum. All vessels used a Campelen 1800 shrimp trawl with a codend mesh size of 40 mm and a 12.7-mm liner. SCANMAR sensors estimated that the mean wingspread was 16.8 m. Details of the survey design and fishing protocols are outlined in Brodie (1996) and McCallum and Walsh (1996).

Survey coverage, within Hawke Channel + Div. 3K (SFA 6), has been extensive in areas where shrimp occur and reliable estimates of distribution, abundance and biomass have been obtained each year. Farther north, survey coverage has

not been sufficient to resolve the highly patchy distribution of shrimp. During 1999, it was decided that future surveys would include Div. 2H in alternate years. During intervening years, the survey would extend to the northern boundary of 2J. NAFO division 2H was surveyed during 2001, however, due to vessel problems, 2H was surveyed during December rather than October. The CCG ALFRED Needler rather than the CCG Teleost surveyed much of 2H and approximately ten fishing locations were not occupied in the southeastern corner of 2H. . NAFO divisions 2J3K were surveyed during 2002. Vessel problems re-occurred during 2002. Most of 2J and parts of 3K were surveyed during the first two weeks of January, 2003 rather than October 2002. A Canadian multi-species research survey has not been conducted in 2G since 1999 and has never been conducted in 0B.

Shrimp were frozen and returned to the Northwest Atlantic Fisheries Centre where identification to species and maturity stage was made. The maturity of the shrimp was defined by five stages:

males;
transitionals;
ovigerous;
primiparous females;
and multiparous females

as defined by Ramussen (1953), Allen (1959) and McCrary (1971). Oblique carapace lengths (0.1 mm) were recorded while number and weight per set were estimated.

Abundance and biomass estimates with Monte Carlo confidence intervals were calculated using a non-parametric method known as OGive MAPping (OGMAP) (Evans *et al.*, 2000). Abundance at length and sex were also derived using this technique. Age structure from survey data was determined by identifying year classes within the composite length frequency distributions.

An exploitation index was calculated by comparing the number in the commercial catch to the previous year's research abundance index. Exploitation was also inferred by dividing total catch weight by each of the following previous fall estimates: biomass, spawning stock biomass (SSB), and fishable biomass. The fishable component of the population was defined as being all males greater than or equal to 17.5 mm CL and all females. Fishable male biomass was determined by converting abundances to biomass using the autumn length weight regression:

$$Wt. = 0.000838Lt^{2.929}$$ (Skúladóttir, 1997).

Female biomass was determined using OGMAP. Female and male (=> 17.5 mm) biomasses were added to obtain fishable biomass.

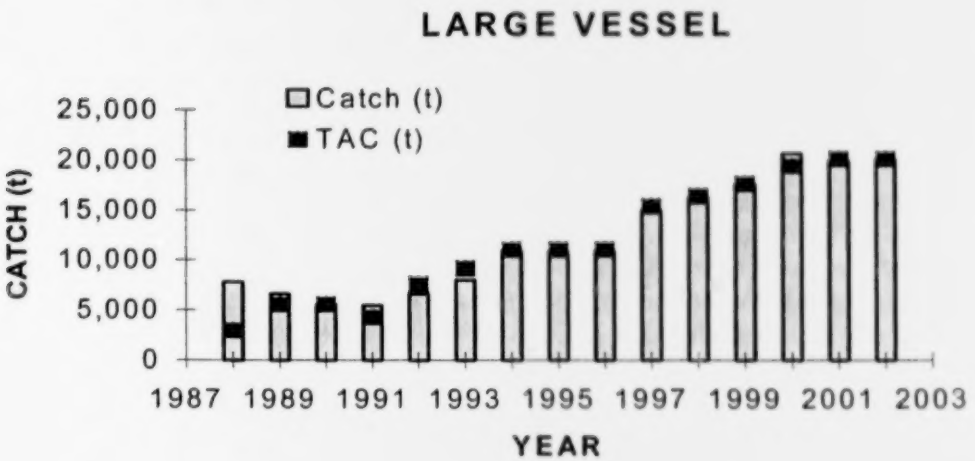
It is important to note that these are not absolute exploitation rates since the catchability of the Campelen trawl is not known. However, these indices allow one to monitor changes in exploitation over the years.

ASSESSMENT OF SHRIMP IN HAWKE CHANNEL+DIV. 3K (SFA 6)

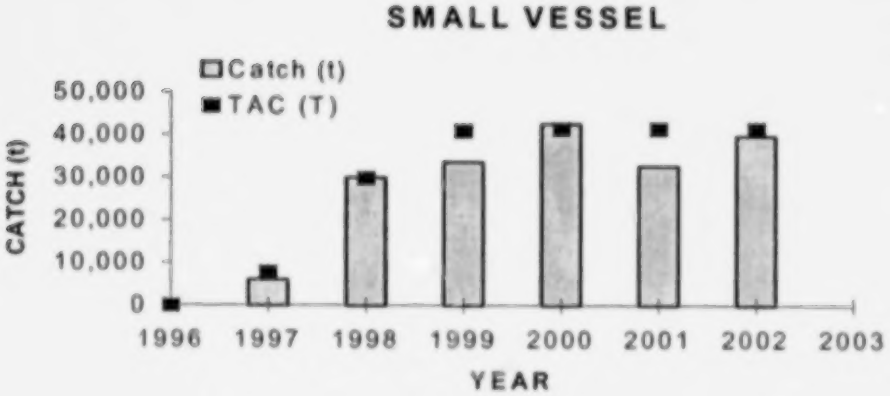
FISHERY DATA

Catch and effort

Catches increased from about 1,800 tons in 1987 to more than 7,800 tons in 1988 and ranged between 5,500 and 8,000 tons from 1989 to 1993, inclusive. The TAC for SFA 6 in the 1994 - 1996 Management Plan was set at 11,050 tons annually and catches increased to 11,000 tons. The TAC for 1997, the first year of the 1997 - 1999 multi-year plan, was raised to 23,100 tons as a first step toward increasing exploitation within a healthy resource. Most of the increase was reserved for the development of a small vessel component. Catches in 1997 were estimated to be approximately 21,000 tons, about 6,100 tons due to vessels less than 100 feet. Despite the large increase in catch, relative exploitation in 1997 remained low and the TAC for 1998 was increased again by 100% to 46,200 tons. Catches exceeded 46,300 tons with the expanding small vessel fleet reporting about 30,000 tons. The 1999 TAC was increased (27%) to 58,632 tons. Due to operational problems, small vessel catches were 7,400 tons short of their 41,029 ton TAC, whereas the large vessel fleet achieved its 17,600



ton allocation. In 2000, the TAC was increased only by 4% to 60,908 tons. Approximately 63,000 tons were taken, 20,000 tons by large vessels and 43,000 tons by small vessels. The 2001 TAC was set at 61,623 tons, of which 20,000

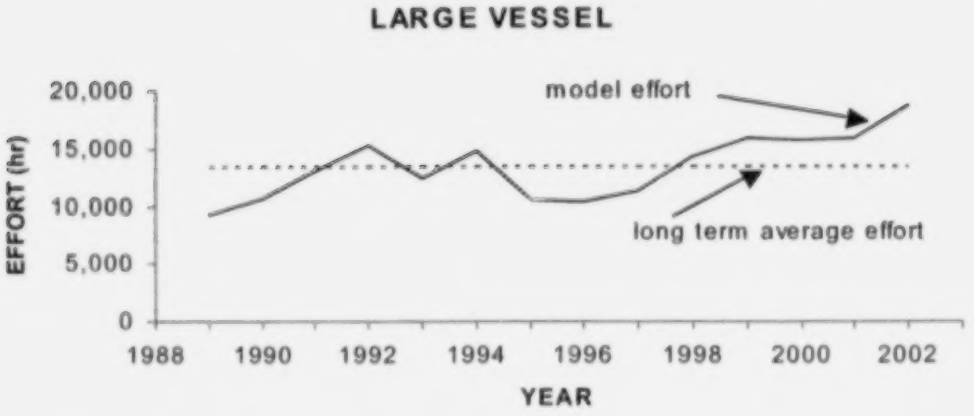


tons were taken by the large vessel fleet while only 32,700 tons were taken by the small vessel fleet (Tables 1 and 2). The small vessel fleet did not take its entire quota because shrimp were relatively small, and there was an international glut in the market for peeled, frozen shrimp. This lead to a short industry imposed closure over the period July- October, 2001. The closure was also induced by seasonal variances in shrimp yield. On average, yield drops by 5% over the summer period (A. O'Rielly, pers. comm.). The plants and fishermen had to re-negotiate the price structure to account for the seasonal loss in yield. Therefore, plants and fishermen agreed to a small vessel closure, which began on July 1, 2001. Negotiations were completed by September 24 and the fishery reopened with an agreement to harvest no more than 25 million pounds during the fall, 2001. The 2001 closure was not complete as the Charlottetown plant continued to purchase shrimp from 2J fishers because the season is shorter in the north.

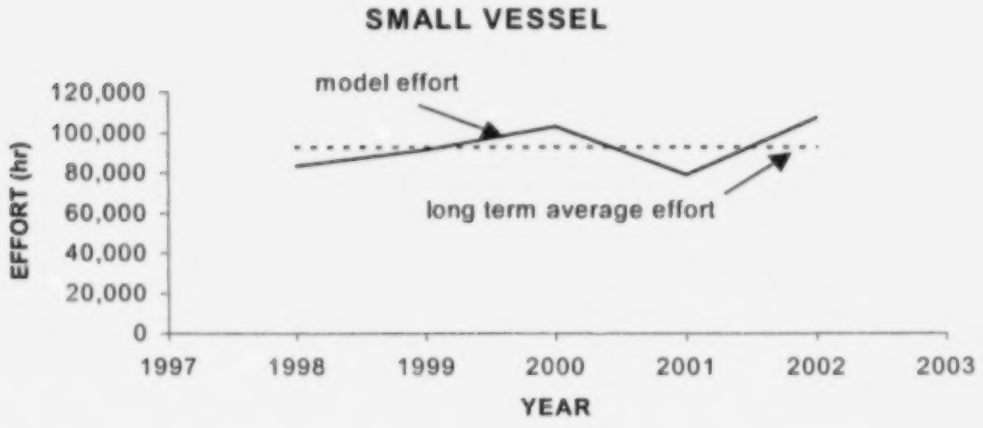
A second industry imposed closure occurred in August of 2002, again with continued operations at Charlottetown. Again this was primarily due to low shrimp yield during the summer months and poor markets.

Prices have already been negotiated for the 2003 season and while a summer closure is not anticipated, industry has developed a management plan that requires trip limits to be reduced from 55,000 lbs during the spring to 38,000 pounds throughout July and 35,000 pounds for August. Additionally, shrimp prices will again drop significantly over this period to account for the loss in yield (A. O'Rielly, pers. comm.). Changes in seasonal price and trip limits are expected to result in shifts within the seasonality of the fishery which, in turn, could influence future CPUE model estimates.

Fishing effort (hours fished = total catch/ cpue) estimated for large vessels increased from 1989 to 1991, stabilized to 1997 and increased thereafter with increases in TAC.



Similarly, effort for the small vessel fleet increased with the increasing TAC.



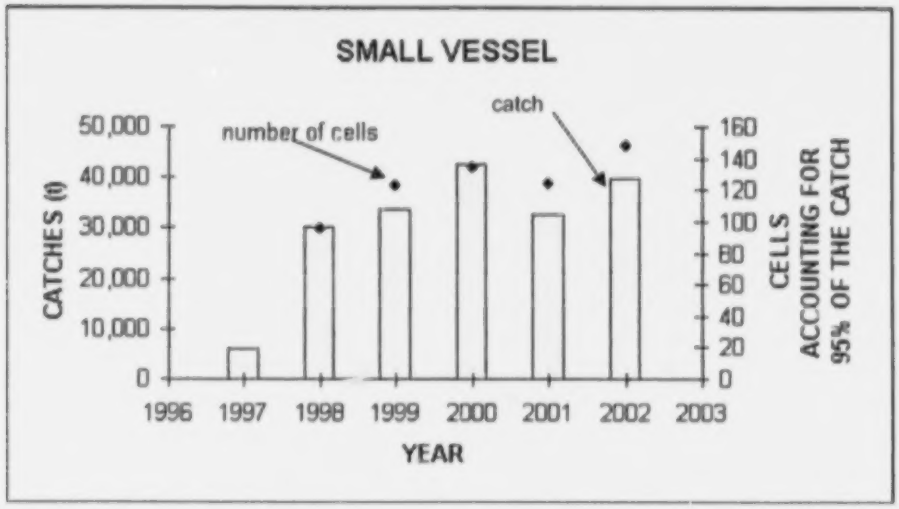
Prior to 1996, the large vessel fleet usually fished SFA 6 during the first 5 months of the year. However, since then they have been fishing this area throughout the year, as illustrated for 2002 in figure 1, while small vessels fish from late spring to early fall (Fig. 2).

The large vessel fleet fished along the shelf edge during the early 1990's (Fig. 3). The fishery extended as far south as the St. Anthony Basin and Funk Island Deep because of the establishment of exploratory areas on the shelf slope in 1992 and 1993, and the discovery of dense concentrations of shrimp within these areas. Stock assessments at this time suggested there was no reason to divide SFA 6 into separate management units. Therefore, the 1994 – 1996 management plan allowed flexibility to fish anywhere within the combined management area. As a result catch and effort shifted away from the St. Anthony Basin and Funk Island Deep areas. Since then, the large vessel fleet

has taken most of their catch from Hawke Channel and along the shelf edge in the northern portion of SFA 6. These changes in fishing pattern are reflected in the change in number of cells required to obtain 95% of the catch.

During 1993, the cell count is high at a time when an exploratory fishery was established in the south. The number of cells declined as catch and effort declined in St. Anthony Basin and Funk Island Deep. The index then increased with catch indicating that fishable biomass was spread over a broad area.

In contrast, the small vessel fishery continues to cover vast areas of SFA 6 with concentrations in Hawke Channel, along the shelf edge in northern 2J, St. Anthony Basin, southeastern 3K, as well as Funk Island Deep (Fig. 4).



Catch per unit effort (CPUE)

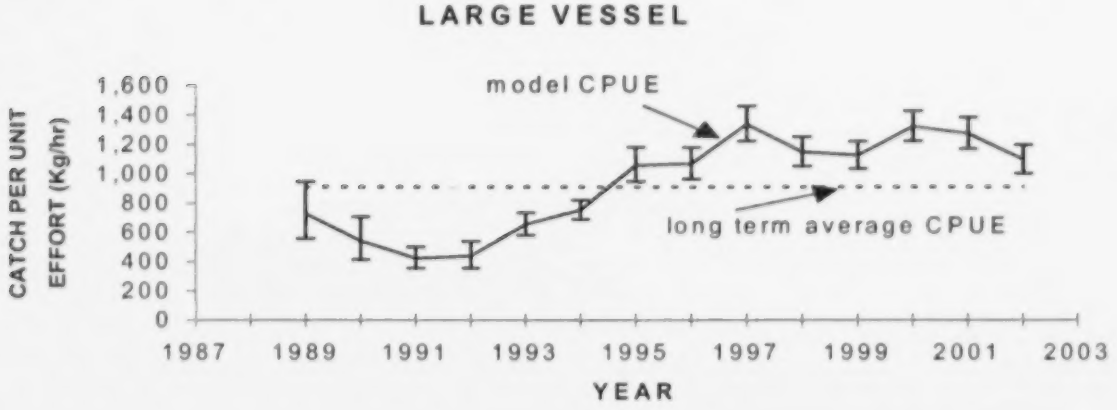
Annual CPUE's for large vessels (single trawl, no windows) increased steadily from 1992 to 1995 and have since fluctuated at a high level. The CPUE data were analyzed by multiple regression for year, month, vessel and area effects to standardize the catch rates (Table 3). The model accounts for approximately 67% of the variance in the data. Figure 5 shows that there are no clear trends in the scatter of residuals around the parameter estimates. However, there are a few outlying negative residuals. The model estimates of catch rates (>1000 kg/hr) are high, therefore, any low (<100 kg/hr) values appear as outlying negative residuals. A cursory examination of the data indicated that most were associated with one vessel that had catches <10 kg/tow. It was fishing along the southern edge of 3K, in area 69. This area has rarely been fished since 1993.

The model indicated that 1995, 1996, 1998 and 1999 catch rates were similar to the 2002 rate ($P>0.05$) while the 1997, 2000 and 2001 rates were higher than the 2002 CPUE. All values prior to1995 were significantly lower than the 2002 estimate ($P < 0.05$). Catch rates since 1995 have all been above the long-term

mean. This would suggest two regimes within the shrimp population, with a turning point occurring early in 1990's.

It is common for most indices to go through cycles of peaks and troughs. The recent downturn in catch rates must be monitored to determine whether the downward trend continues. However, at present, CPUE is being maintained at a high level at a time when the fishery covers a broad geographic area suggesting that the stock is healthy.

The following indicates the 95% confidence intervals around each CPUE estimate derived from observed data.



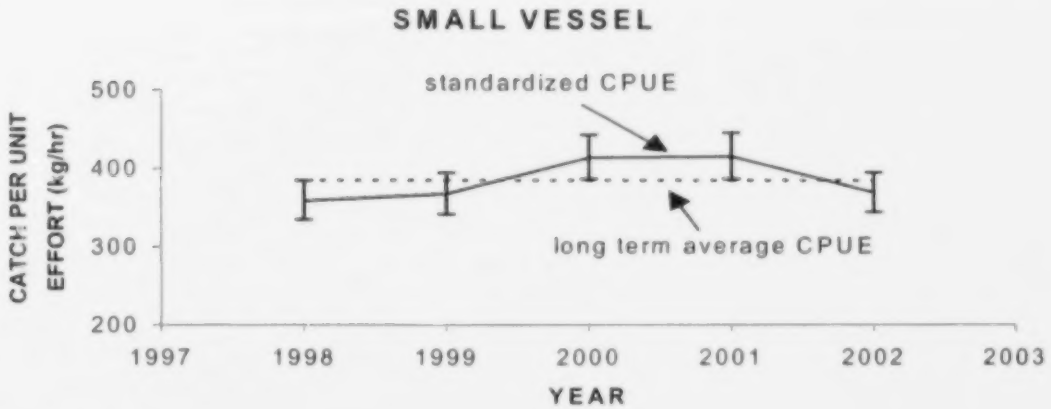
In order to reduce the number of parameters within the small vessel CPUE models, various exploratory plots were created to see if classes of vessels could be created. None of the plots were informative because there is a wide range of sizes, styles, horse powers and crew abilities. Small vessels sometimes were heavier or had larger engines or better crews than larger vessels. Therefore, the small vessel CPUE model did not include vessel as an explanatory parameter.

Table 4 provides the small vessel CPUE model output while figure 6 indicates the scatter of residuals around estimated parameters. There are no clear trends in the scatter of residuals. The inter-quartile boxes are close to the zero reference lines indicating that there is not a great deal of variation in the data.

The model accounted for only 46% of the variation in explanatory parameters. The low explanatory power is probably due to the short time series (5 years). The 1998 and 1999 catch rates were similar to the 2002 estimate ($P>0.05$), while the 2000 and 2001 CPUE estimates were significantly higher than the 2002 estimate ($P<0.05$). Such fluctuations are normal. The fact that there is a narrow range of fluctuations (56 kg/hr) and the 95% confidence intervals are relatively tight indicate that there is within and between year stability in the fishery.

Size composition

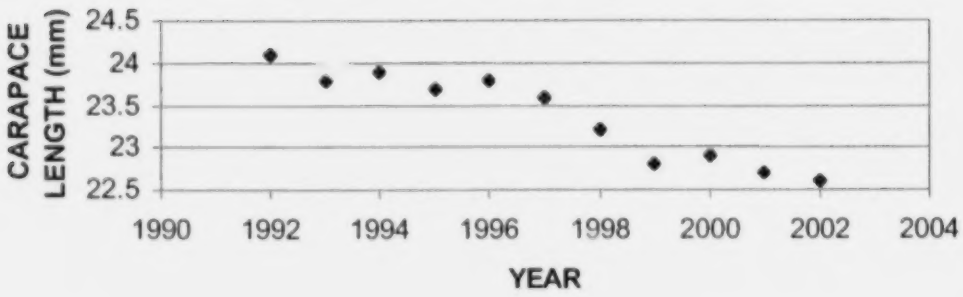
Catch-at-length, estimated from samples taken by observers on large vessels, showed dominance of the female component around 23 - 24 mm carapace length (CL) in most years (Fig. 7). The relative strength and development of year classes are tracked through observations of consecutive annual length frequencies. The relatively strong 1991 year class, first appeared at approximately 16 mm in 1994 (age 3), dominated the male component at 18 mm in 1995 (age 4) and at 20 mm in 1996 (age 5). In 1997, at age 6, most were female. Likewise, the 1993 year class was well represented at 16 mm in the 1996 samples and at 18 mm in 1997 and 20 mm in 1998. The 1994 year class dominated the male component during 1999 while the 1995 year class



dominated in 2000. In 2001, the relatively strong 1998 year class (age 3) first appeared at 15 mm, the 1997 year class (age 4 – 18 mm) was dominant while the 1996 year class (age 5 – 20 mm) appeared weak. The male component of the 2002 catch is dominated by the 1998 (age 4 – 17 mm) and 1997 (age 5 – 20 mm) year classes. The fact that the female component, in 2002, is broad suggests that it consists of more than one year class. It probably consists of the majority of the 1997 year class as well as remnants of the 1996 –1994 year classes. This is in agreement with the 2001 assessment which suggested that the female component would be broad and probably consist of more than one year class. The contribution of females to the catches should be maintained over the next few years as individuals from the 1998 and 1999 year classes change from male to female.

Median size at sex inversion decreased from 22 mm to 20.5 mm over 1993 - 2002 (Fig. 7). The mean size of females in catches also decreased over this period. These observations indicate a possible change in growth/ maturity

TRENDS IN AVERAGE CARAPACE LENGTH AMONG FEMALES TAKEN IN THE LARGE VESSEL SHRIMP FISHERY



schedule within the area. Although smaller females carry fewer eggs, reproductive potential has been maintained by the continued high abundance of females.

It was felt that small vessel observer protocols prior to 2000 were not sufficient to collect representative length frequencies. Therefore, the analysis of shrimp length frequencies from the small vessel sector (Fig. 8) begins with 2000 samples. The jagged appearance of the 2000 and 2001 length frequencies makes it impossible to identify year classes with certainty. However, it is important to note that males ranging in carapace length from 10 to 23.5 mm dominated the 2000 samples. The largest males (> 19 mm) and smallest females (< 22 mm) are thought to belong to the 1995 year class. During subsequent years, females were more prevalent within the samples. However, there are no clear modes hence ages could not be inferred from the length frequencies.

RESEARCH SURVEY DATA

Stock size

Results of the 2002 fall multispecies research survey indicate that shrimp continue to be widely distributed and abundant throughout Hawke Channel + Div. 3K (Figs. 9 & 10). Minimum trawlable biomass (defined by the lower 95% confidence limit) was estimated at 540,000 tons and abundance at 132 billion animals, the second highest in the series. Monte Carlo confidence limits reflect the high level of precision around the estimates from this area.

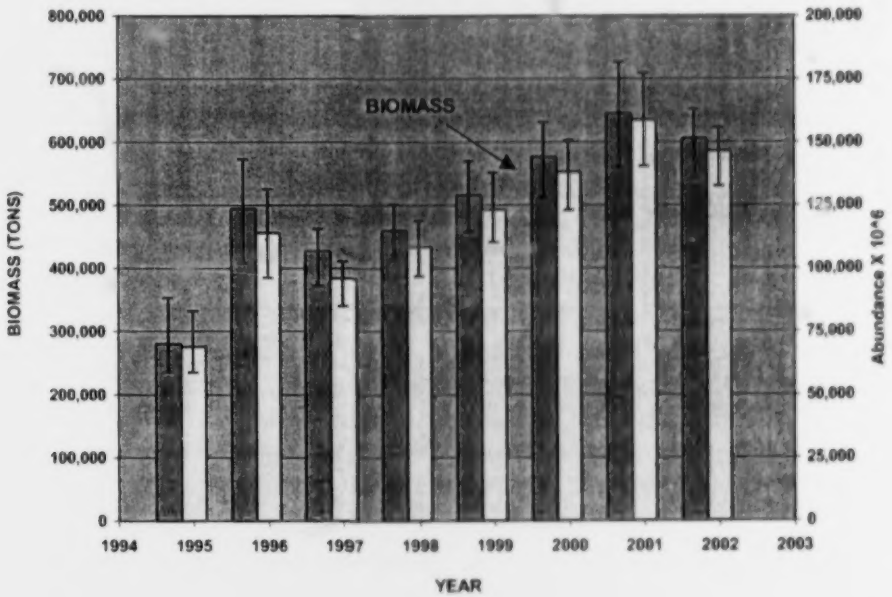
Biomass and abundance estimates and their 95% confidence intervals are compared in the following two tables and figure. Inshore strata along the northeast Newfoundland coast were not sampled in 1995 or 1999. Therefore, the analyses were confined to the offshore strata for comparative purposes. Inshore areas, sampled during other surveys, generally produced low catches of shrimp that did not contribute substantially to the biomass/ abundance estimates.

Northern shrimp stock size estimates in Hawke+3K (SFA 6) [1] from fall research trawl surveys - offshore, 1995 - 2002.

	Biomass (tons)			Abundance (numbers x 10^{-6})			Survey
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	Sets
1995	235,500	280,400	353,200	58,710	68,983	83,200	195
1996	408,600	494,100	572,900	96,310	114,032	131,200	238
1997	371,500	427,300	462,500	84,950	95,967	102,600	232
1998	413,100	459,800	501,500	96,960	108,615	118,800	234
1999	457,500	515,600	569,600	110,200	123,188	137,900	233
2000	510,400	576,100	630,900	123,100	137,917	150,700	241
2001	559,800	645,000	727,200	140,400	158,715	177,400	252
2002	540,000	606,000	651,700	132,500	146,270	155,700	253

[1] **Area compared each year = 171,048.5 sq. km.**

Point estimates for biomass (abundance) increased from about 280,400 tons (69 billion) in 1995 to 494,100 tons (114 billion) in 1996 but declined to 427,300 tons (96 billion) in 1997. Since then, estimates increased steadily to 645,000 tons



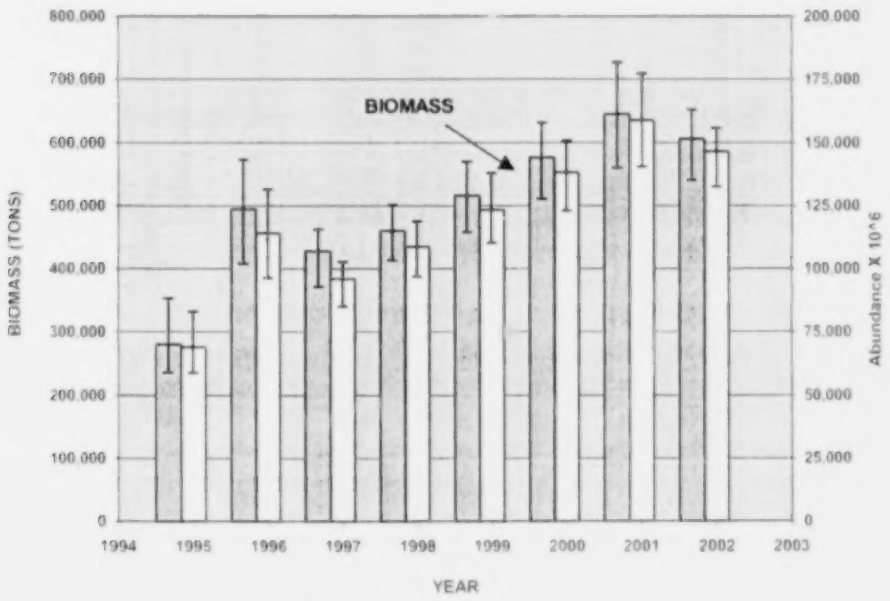
Biomass and abundance estimates and their 95% confidence intervals are compared in the following two tables and figure. Inshore strata along the northeast Newfoundland coast were not sampled in 1995 or 1999. Therefore, the analyses were confined to the offshore strata for comparative purposes. Inshore areas, sampled during other surveys, generally produced low catches of shrimp that did not contribute substantially to the biomass/ abundance estimates.

Northern shrimp stock size estimates in Hawke+3K (SFA 6)[1] from fall research trawl surveys - offshore, 1995 - 2002.

	Biomass (tons)			Abundance (numbers x 10^{-6})			Survey
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	Sets
1995	235,500	280,400	353,200	58,710	68,983	83,200	195
1996	408,600	494,100	572,900	96,310	114,032	131,200	238
1997	371,500	427,300	462,500	84,950	95,967	102,600	232
1998	413,100	459,800	501,500	96,960	108,615	118,800	234
1999	457,500	515,600	569,600	110,200	123,188	137,900	233
2000	510,400	576,100	630,900	123,100	137,917	150,700	241
2001	559,800	645,000	727,200	140,400	158,715	177,400	252
2002	540,000	606,000	651,700	132,500	146,270	155,700	253

[1] **Area compared each year = 171,048.5 sq. km.**

Point estimates for biomass (abundance) increased from about 280,400 tons (69 billion) in 1995 to 494,100 tons (114 billion) in 1996 but declined to 427,300 tons (96 billion) in 1997. Since then, estimates increased steadily to 645,000 tons



(159 billion) in 2001 with a slight drop in 2002 to 606,000 tons (146 billion). The lower 95% confidence intervals for the biomass indices averaged 496,200 tons (about 121 billion animals) during the 1998 - 2002 period.

The fact that confidence intervals are relatively tight suggests that stock is spread throughout the survey area (Figs. 9 & 10). This is in agreement with the areal index used to track changes in the commercial fishing data

Male biomass/ abundance indices increased from 246,100 tons (74 billion animals) in 1997 to 298,700 tons (108 billion animals) during 2001 then decreased to 252,600 tons (93 billion animals) during 2002. However, the female stock increased continually from an estimated 181,200 tons (22 billion) in 1997 to 353,300 tons (54 billion) in 2002.

Stock size estimates for male and female shrimp in Hawke+3K (SFA 6) from fall research trawl surveys - offshore, 1995 - 2000.

	Biomass (tons)			Abundance (numbers x 10^{-6})		
	Males	Females	Total	Males	Females	Total
1995	136,400	144,000	280,400	51,010	17,972	68,982
1996	290,200	204,000	494,200	90,081	23,949	114,031
1997	246,100	181,200	427,300	74,051	21,916	95,967
1998	248,100	211,700	459,800	77,997	30,617	108,614
1999	259,500	256,100	515,600	88,626	34,562	123,187
2000	278,600	297,500	576,100	97,463	40,454	137,917
2001	298,700	346,300	645,000	108,068	50,646	158,714
2002	252,600	353,300	605,900	92,526	53,744	146,270

The 2002 estimates may not be comparable with estimates from other years because the survey finished SFA 6 during January 2003, rather than early December 2002.

Exploitation Rate Indices:

In terms of number of animals:

	Survey Abundance index			Removals by fishery			Exploitation Rate index		
Year	Male (10^6)	Female (10^6)	Total (10^6)	Male (10^6)	Female (10^6)	Total (10^6)	Male (%)	Female (%)	Total (%)
1995	51,010	17,972	68,982						
1996	90,081	23,949	114,031	664	79	744	1.3	.44	1.07
1997	74,051	21,916	95,967	*	*	*	*	*	*
1998	77,997	30,617	108,614	*	*	*	*	*	*
1999	88,626	34,562	123,187	*	*	*	*	*	*
2000	97,463	40,454	137,917	5,784	4,999	10,784	5.9	14.5	8.7
2001	108,068	50,646	158,714	3,481	4,738	8,219	3.6	11.7	6.0
2002				4,175	5,304	9,479	3.9	10.5	6.0

- small vessels began fishing during 1997, however, it was felt that observer sampling was not adequate until 2000, therefore, exploitation rate by number was not estimated over the period 1997 – 1999.

In terms of biomass:

Year	Catch (large + small vessel) (t)	Lower C.I. of Total Biomass (t)	SSB (t)	Fishable Biomass (t)
1995		235,500	144,000	198,295
1996	10,923	408,600	204,000	355,006
1997	21,018	371,500	181,200	340,070
1998	46,337	413,100	211,700	399,768
1999	51,260	457,500	256,100	442,615
2000	63,266	510,400	297,500	476,741
2001	52,630	559,800	346,300	538,112
2002	59,943			

Year	Catch/ Lower C.I. of Total Biomass (%)	Catch/ SSB (%)	Catch/ Fishable Biomass (%)
1996	4.6	7.6	5.6
1997	5.1	10.3	5.9
1998	12.5	25.6	13.6
1999	12.4	24.2	12.8
2000	13.8	24.7	14.3
2001	10.3	17.7	11.0
2002	10.7	17.3	11.1

In terms of numbers of shrimp removed, exploitation rates for female shrimp have exceeded those of males, however, overall exploitation has remained low over the short history of the research survey. This former observation agrees with the commercial length frequencies (Figs. 7 & 8).

In terms of biomass, exploitation increased between 1997 and 1998 consistent with the increase in catches during this period. Exploitation remained stable during 1998 – 2000 as both catch and biomass increased but then decreased in 2001 because the total catches decreased at a time when biomass was increasing. Exploitation remained low during 2002.

This exercise indicates that whether exploitation is estimated using numbers or weight, the exploitation remained relatively low over the short time series. It should be noted that actual exploitation rates are unknown but are likely lower than indicated above because the OGMAP indices are believed to be underestimates (i.e. catchability of the survey gear is unknown but believed to be < 1).

Stock composition

Length distributions representing abundance-at-length from the 1997 – 2002 surveys are compared in Fig. 11.

Abundance estimated from the 2002 survey data was dominated by a broad size range of males from 13 to 20 mm carapace length believed to include the 1998, 1999 and 2000 year classes (ages 4, 3 and 2 respectively). The 1998 year class was evident near 18 mm, while the 1999, 2000 and 2001 year classes were evident near 16 mm, 13 mm and 9 mm respectively. Largest males (> 19 mm) and smallest females (< 22 mm) are thought to belong to the 1997 year class. The 2002 female distribution appears broad suggesting that it consists of animals from more than one year class. It is probable that the female component includes individuals from the strong 1997 year class, those from the weaker 1995 and 1996 year classes, as well as, remnants from the strong 1994 year class.

The time series provides a basis for comparison of relative year-class strength and illustrates changes in stock composition over time. The 1995 year class, at age 5 in 2000, age 4 in 1999, age 3 in 1998 and age 2 in 1997, was weaker than both the 1994 or 1993 year classes at those ages. Further, the 1996 year class, at age 5 in 2001, age 4 in 2000, age 3 in 1999 and age 2 in 1998, is the weakest observed. The 1997 year class is stronger than the 1995 and 1996 and, at age 4 in 2001, appears at least as strong as the 1993 and 1994 year classes were in 1997 and 1998, respectively. The 1998 and 1999 year classes appear to be similar to the 1997 year class in strength. However, the 2000 year class at ages 1 and 2 appears weaker than most. The 2001 year class at age 1 appears average.

RESOURCE STATUS

Large and small vessel catch rates in 2002 were significantly lower than in the previous two years. Large vessel CPUE remains above the long term average while small vessel CPUE is slightly below average.

Due to vessel problems, the research survey in this area was not completed until the second week of January 2003, rather than early in December 2002. This change in survey timing may have influenced research catches, leaving comparability of between year surveys in doubt.

Total biomass/ abundance estimates, from research survey data, appear to have levelled off at a high level. The upper 95% confidence limits for these biomass/ abundance indices, in 2002, are within the range of confidence intervals since 1999. Thus the indices are at the second highest levels over the time series but are not significantly higher than the 1999 indices. The lower 95% confidence

intervals for the biomass indices averaged 496,200 tons (about 121 billion animals) during the 1998 - 2002 period. High 2002 female biomass/ abundance indices were partially due to sex inversion of the 1997 year class. The 1997 year class was one of the strongest in the research time series. The 2002 female length frequencies are broad compared to 2000 female length frequencies suggesting that it consists of more than one year class. It is anticipated that female biomass/ abundance will remain high due to sex inversion of the strong 1998 year class in 2004 and remnants of the strong 1997 year class.

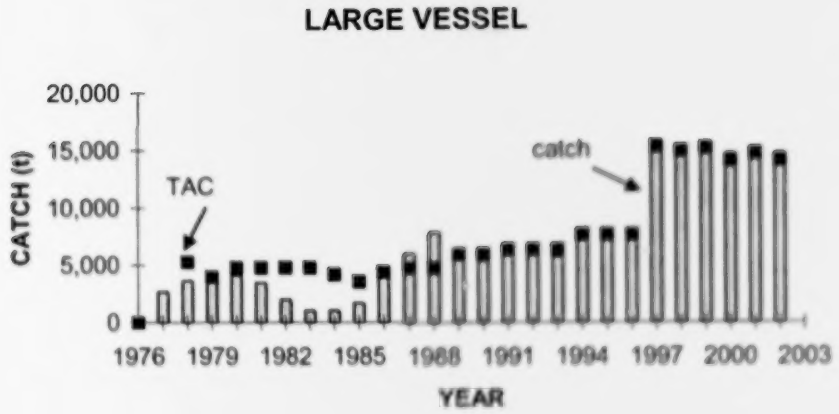
The 2002 large vessel CPUE index is significantly lower than in 1999 and 2000 but remains above the long term average. The 2002 small vessel CPUE is slightly below average, however, there is a narrow range in small vessel CPUE indices and the time series extends over only 5 years. At the same time research indices of stock size are at their second highest levels in the time series. The resource in this area remains healthy with high biomass/ abundance of male and female components. Exploitation has remained low and the fishery continues throughout the year over a broad geographic area. Since catch has remained low relative to biomass/ abundance, it is felt that the slight downturns in CPUE, as well as, biomass/ abundance are more due to natural phenomenon and are not caused by the fishery. It is expected that commercial/ research indices will fluctuate over time.

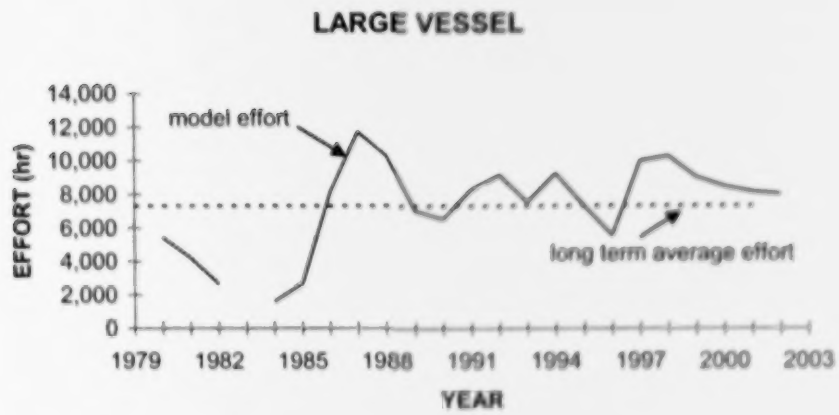
ASSESSMENT OF SHRIMP IN HOPEDALE & CARTWRIGHT CHANNELS (SFA 5)

FISHERY DATA

Catch and effort

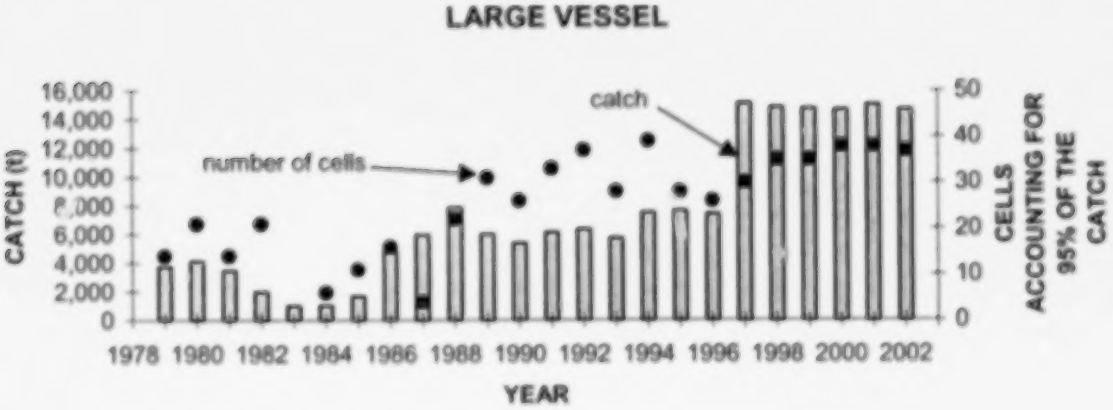
Shrimp catches in Hopedale and Cartwright Channels increased from about 2,700 tons in 1977 to 4,100 tons in 1980, declined to 1,000 tons in 1983 and 1984, increased again to 7,800 tons in 1988 and then stabilized at roughly 6,000 tons during the 1989 - 1993 period. TAC's for the 1994 - 1996 management plan, which combined the two channels as a single management area, were increased to 7,650 tons annually and catches subsequently increased, averaging 7,500 tons during that period. Annual TAC's for the 1997 - 1999 plan were increased 100% to 15,300 (large + small vessel allocations) tons and catches were about 15,000 tons each year. The 15,300 ton TAC (note that this includes small vessel allocations) was maintained in the 2000 – 2002 plan and preliminary data indicate that the large vessel fleet caught approximately 14,700 tons during 2002. Table 5 documents the history of the large vessel shrimp fishery in Hopedale and Cartwright Channels (SFA 5). Over the past ten years, fishing effort has remained relatively stable even though the TAC doubled between 1996 and 1997.





In the late 1970's and throughout the 1980's, the fishery concentrated in four main areas: northern, eastern and southern Hopedale Channel and Cartwright Channel. Fishing continued in the traditional areas during the 1990's, however, more effort was reported from the slopes of the shelf, north and east of Cartwright Channel (Fig.12). From 1994 to 2001, substantial effort occurred on the eastern slope during winter and spring. Historically a summer - fall fishery for the large vessels, since 1995 it has become mainly a winter - spring operation (Fig. 13). Varying allocations have been available in recent years for small vessels but this fleet sector contributes only in a minor way to the fishery, relative to the large vessel fleet.

The plot of catch overlain upon the number of cells accounting for 95% of the catch indicates that despite a doubling of quota after 1996, the area fished remained similar to that of the previous nine years.

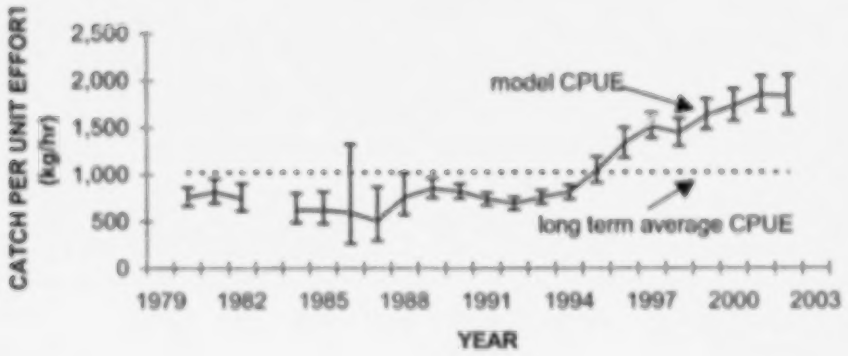


Catch per unit effort (CPUE)

Annual CPUE data (single trawl, no windows, observer data for vessels >500 t) were analyzed by multiple regression with effort weighting for year, month, vessel and area effects (Table 6). Lack of data during the early years and filtering resulted in missing points during 1977 – 1979, 1983 and 1986. The model accounts for approximately 77% of the variance in data. The scatter of residuals around parameter estimates is provided in figure 14. There were no trends in the residuals, for the most part they appear centered around the reference line and the inter-quartile boxes appear to be small indicating that the model fits the data. However, there are numerous outlying negative residuals indicating that there were lower than expected catches. A quick look at the data indicates that many of the outliers were associated with catches taken prior to 1995. Since 1995, the seasonality of the fishery shifted from summer-fall to winter-spring and there has been a shift of effort toward the shelf break. Further work will have to be done to determine the impact that these factors had upon the model.

The standardized catch rates were relatively stable from the mid 1980's to the early 1990's. Standardized catch rates increased thereafter to 1998 after which they again stabilized. The 1999 – 2001 catch rates were statistically similar ($P>0.05$) to 2002 while all others were lower than 2002 ($P < 0.05$). A high cpue over a relatively broad area is an indication that the stock is healthy.

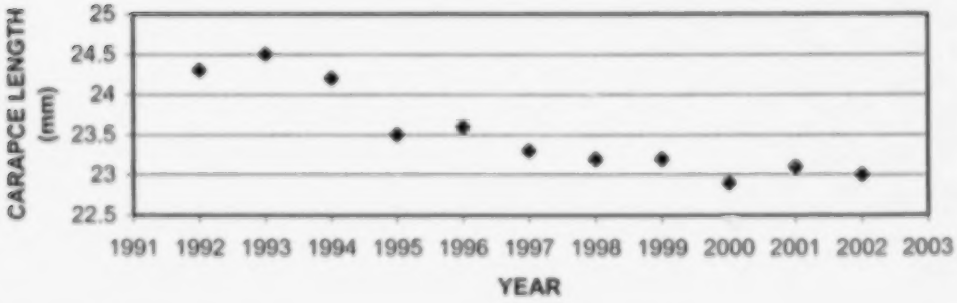
LARGE VESSEL



Stock Composition

Catch-at-length data from 1993 to 2002 (Fig. 15) indicated female modes occurred at about 23-25 mm CL each year. While the catch rates for this component increased since the early 1990's, the average female carapace length decreased from 24.5 mm in 1993 to 22.9 in 2000 and has since remained at approximately 23 mm. The median size at size change decreased by approximately 1 mm over this period.

TRENDS IN AVERAGE CARAPACE LENGTH AMONG FEMALES TAKEN IN THE LARGE VESSEL FISHERY



Recruitment of males between approximately 16 and 22 mm was consistent from year to year and males contributed substantially to the catch in numbers up to 1999. The male component showed a decline between 1998 and 2000, possibly

a reflection of weaker 1995 and 1996 year classes. In 2000, the stronger 1997 year class appears at 16 mm (age 3) and dominants the male distribution in 2001 at 18 mm (age 4). In 2002, many of these animals had changed into females, but some males are still seen at 20 mm. Sex inversion of 1997 year class animals resulted in the 2002 female distribution being broader than the previous two. The relatively strong 1998 year class first appears as males in 2001 at 16 mm (age 3). The 2002 male distribution is dominated by 16 – 20 mm animals that are probably from the 1997, 1998 and 1999 year classes (20 mm, 18 mm and 16 mm respectively).

RESEARCH SURVEY DATA

Stock size

Long term research plans call for the northern part of SFA 5 (Hopedale Channel – Div. 2H) to be surveyed every two years. Only Cartwright Channel was surveyed during 2002 (Figs. 16 & 17). Results of the 2002 survey indicate that biomass/ abundance indices have decreased from the 2001 estimates. The minimum trawlable biomass was estimated to be 69,100 t (17 billion animals) in 2001, while it was 44,200 t (15 billion animals) in 2002. The 2002 minimal trawlable indices, within Cartwright Channel, are second highest in the time series.

Due to vessel problems, the research survey in this area was not completed until the second week of January 2003, rather than in November 2002. This change in survey timing may have influenced research catches, leaving comparability of between year surveys in doubt.

As in previous years, trends in biomass/ abundance estimates for Hopedale and Cartwright Channels were compared to determine whether enough similarities exist to model biomass/ abundance estimates for Hopedale Channel when there is no survey in that area.

Northern shrimp stock size estimates in Cartwright Channel (SFA 5) from offshore fall research trawl surveys, 1996 - 2001.							
	Biomass (tons)			Abundance (numbers x 10^{-6})			No.
Year	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	Sets
1996	26,330	75,200	188,700	5,454	20,517	57,070	34
1997	34,480	47,200	66,950	7,138	9,864	15,130	40
1998	31,760	42,400	55,910	6,280	8,368	11,160	36
1999	41,320	57,300	73,750	8,240	11,077	14,180	36
2000	44,030	72,100	114,300	10,490	16,848	25,630	35
2001	69,150	85,600	114,500	16,910	21,019	27,600	33
2002	44,220	57,400	74,490	14,990	19,300	24,470	39

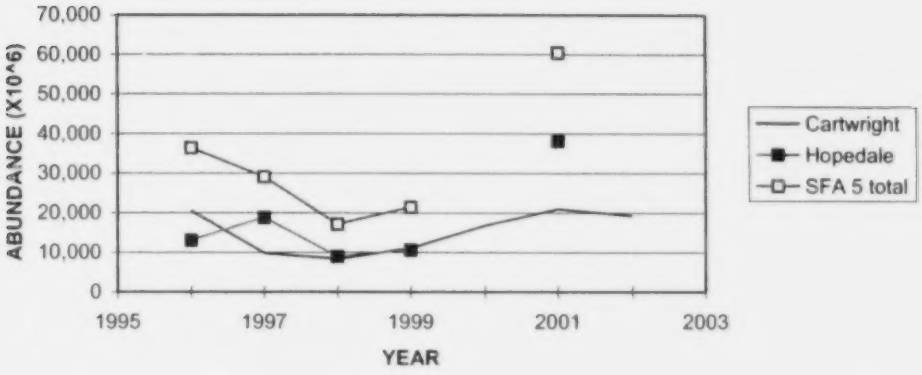
[1] **Area compared each year = 25,204.6 sq. km.**

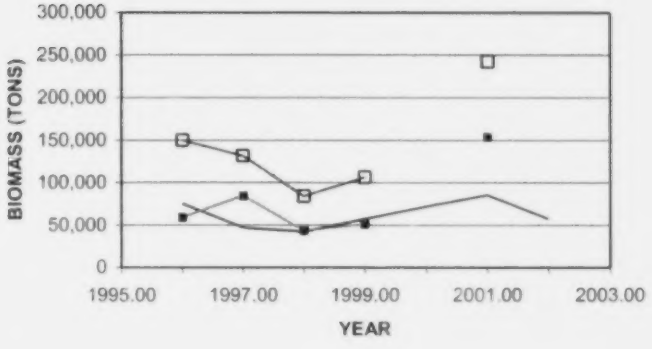
Northern shrimp stock size estimates in Hopedale Channel (SFA 5) [2] from fall research trawl surveys - offshore, 1996 - 2001.							
	Biomass (tons)			Abundance (numbers x 10^{-6})			No.
Year	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	Sets
1996	30,830	59,500	118,300	6,690	13,115	29,320	77
1997	52,310	84,700	114,000	11,670	18,873	25,860	72
1998	25,360	43,800	67,480	5,219	9,041	13,950	83
1999	27,200	51,500	85,950	5,443	10,626	17,630	81
2000							
2001	103,300	153,900	208,600	24,970	38,164	52,490	57

[2] **Area compared each year = 34,282.2 sq. km.**

Northern shrimp stock size estimates in Hopedale-Cartwright (SFA 5) [3] from fall research trawl surveys - offshore, 1996 - 2001.							
	Biomass (tons)			Abundance (numbers x 10^{-6})			No.
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	Sets
1996	64,340	143,200	308,300	13,740	36,503	86,150	111
1997	96,710	132,500	172,000	21,150	29,148	39,460	112
1998	63,210	85,300	113,000	12,640	17,141	23,040	119
1999	77,600	108,000	147,000	14,800	21,438	29,390	117
2000							
2001	183,100	244,300	309,000	44,880	60,526	75,980	90

[3] **Area compared each year = 60,578.6 sq. km.**





Between 1996 and 1997, stock indices increased for Hopedale Channel but decreased for Cartwright. Confidence intervals for the 1996 survey estimates were wide due to two anomalously high catches. Therefore, the usefulness of the results by area or for the total was limited. In 1997, the Hopedale Channel results were overestimated because shallow areas (< 200 m) of the Nain Bank were not sampled and the method interpolated shrimp catches from deeper water over a large area where densities are known to be lower. The 1998, 1999 and 2001 survey indices showed similar trends. Biomass and abundance indices within Cartwright Channel decreased during 2002. Since Hopedale Channel was not surveyed in 2002, comparisons could not be made between Cartwright and Hopedale Channels or the entire of SFA 5.

A comparison between figures 9 & 10 and 16 & 17 illustrates that the distribution of animals is more widespread and evenly dispersed within SFA 6 than it is SFA 5. The fact that shrimp are highly concentrated in two main channels and along the shelf edge within SFA 5 helps account for the broad confidence limits around the point estimates. The fishery occurs in areas of high biomass (Figures 12, 13, 16 and 17). The areal index used in tracking the fishery (number of cells accounting for 95% of the catch) is lower within SFA 5 than in SFA 6, but this is

probably more a function of habitat than an indicator of relative stock health. There is more suitable habitat within SFA 6 than there is in SFA 5 therefore the animals and hence the fishery is more dispersed within SFA 6.

Exploitation rates

In terms of numbers:

	Survey Abundance index			Removals by fishery			Exploitation Rate index		
Year	Male (10^6)	Female (10^6)	Total (10^6)	Male (10^6)	Female (10^6)	Total (10^6)	Male (%)	Female (%)	Total (%)
1996	32,505	3,933	95,967						
1997	24,059	5,099	29,157	1,125	1,283	2,408	3.5	32.6	6.6
1998	12,434	4,718	17,151	971	1,049	2,020	4.0	20.6	6.9
1999	14,985	6,449	21,434	836	1,132	1,968	6.7	24.0	11.5
2000				800	1,269	2,069	5.3	19.7	9.6
2001	47,974	12,540	60,515						
2002				1,016	1,353	2,368	2.11	10.79	3.9

In terms of biomass:

Year	Catch (large + small vessel)	Lower C.I. of Total Biomass (t)	SSB (t)	Fishable Biomass (t)
1996		64,340	33,100	82,994
1997	15,103	96,710	41,600	108,602
1998	15,170	63,210	38,300	77,404
1999	15,109	77,600	52,100	99,344
2000	14,971			
2001		183,100	94,900	186,773
2002	14,880			

Year	Catch/ Lower C.I. of Total Biomass (%)	Catch/ SSB (%)	Catch/ Fishable Biomass (%)
1997	23.5	45.6	18.2
1998	15.7	36.7	14.0
1999	23.9	39.4	19.5
2000	19.3	28.7	15.1
2001			
2002	8.1	15.7	8.0

Each of these methods indicate that even though catches have been stable over the period 1997 – 2002, exploitation may vary due to annual variation in shrimp biomass. Since the catchability of the research trawl is thought to be less than 1, it is likely that the true exploitation rates are lower than indicated above. These exploitation indices are higher than those in SFA 6.

The 2001 estimates may not be comparable with estimates from other years because:

1) the survey in SFA 5 was in December rather than October;
2) the survey made use of the CCG Alfred Needler rather than the CCG Teleost and;
3) there were approximately 10 sets in the southeastern portion of 2H that were not surveyed.

Similarly, the 2002 estimates may not be comparable with estimates from other year because the survey was finished in January 2003 rather than November 2002.

RESOURCE STATUS

The issues of survey timing, change in ship, missing sets in the southeast cause us to be cautious about the interpretation of the research survey results in 2001 and 2002. As well, it is not yet clear whether Cartwright Channel indices are indicative of indices within the entire of SFA 5.

The 2001 RV survey biomass and abundance indices for Hopedale Channel were substantially higher than those observed over the 1997 – 1999 period. However, the 2002 survey covered only Cartwright Channel, where biomass and abundance indices remained stable since 1996.

Based upon 2001 RV survey results, the female component should be maintained, over the next 1 - 2 years, as relatively strong year classes (15 – 19 mm males) change sex. Low catchability of small males and no RV survey in 2002 preclude inferences about recruitment. Exploitation rate indices, in terms of catch/ fishable biomass, were less than 0.25 between 1997 and 2000.

The northern portion of SFA 5 was not surveyed in 2000. Therefore, it was not possible to determine an exploitation rate index in 2001. Due to the increase in biomass observed in 2001, the exploitation rate index decreased to 0.08 in 2002. Since catchability of shrimp by the RV trawl is <1 exploitation rates have likely been low.

The mean size of females in the fishery has declined since 1993 but has remained stable at a smaller size since 2000. It is believed that individual fecundity associated with this decrease has minimal impact upon total egg production, as 2001 biomass/ abundance indices were substantially higher than those observed over the 1997 – 1999 period.

ASSESSMENT OF SHRIMP IN NAFO DIVISION 2G (SFA 4)

FISHERY DATA

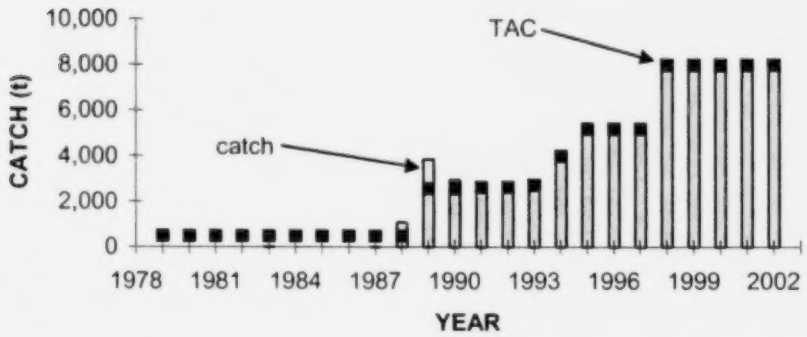
Catch and effort

Shrimp catches increased from 1,083 tons in 1988 to 3,842 tons in 1989 and remained within the 2,500 – 3,000 ton range up to and including 1993 (Table 7). The 1994 catch increased to 3,982 tons with an increase in TAC to 4,000 tons in the first year of the 1994 - 1996 Management Plan. A second increase to 5,200 tons for 1995 and 1996 resulted in catches of about 5,100 tons in both years. The TAC of 5,200 tons was maintained for 1997 and catch was estimated at 5,217 tons.

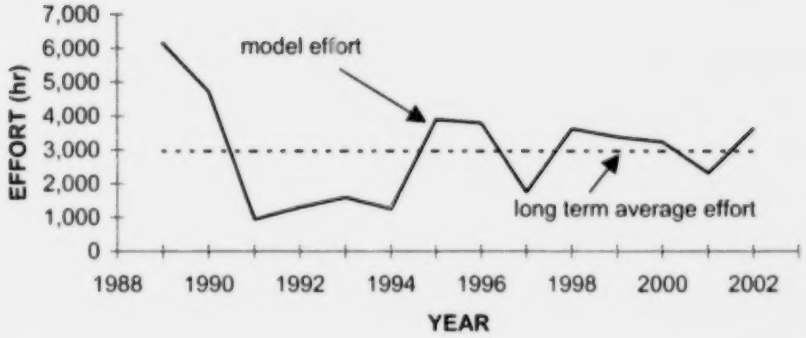
The interim review of stock status in the winter of 1998 indicated that an increase in TAC could be considered. Lacking the basis on which to advise an appropriate level of TAC, an increase of 60% (3,120 tons) to 8,320 tons (312 tons of this quota were allocated to the small vessel fleet) was chosen in the management process. Furthermore, 70% of the increase (2,184 tons) was applied to the area south of 60^0 N where very little fishing had occurred since 1990. Catches from 1998 to 2002 were estimated at approximately 8,000 tons each year.

Effort decreased from 1989 until 1991 after which it fluctuated between 1,000 and 4,000 hours per year. Effort in 2002 was slightly above the long term average.

LARGE VESSEL

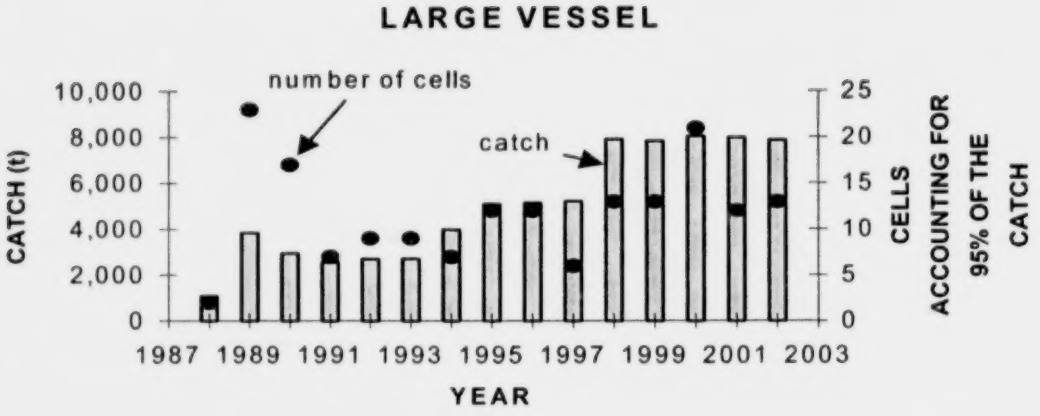


LARGE VESSEL



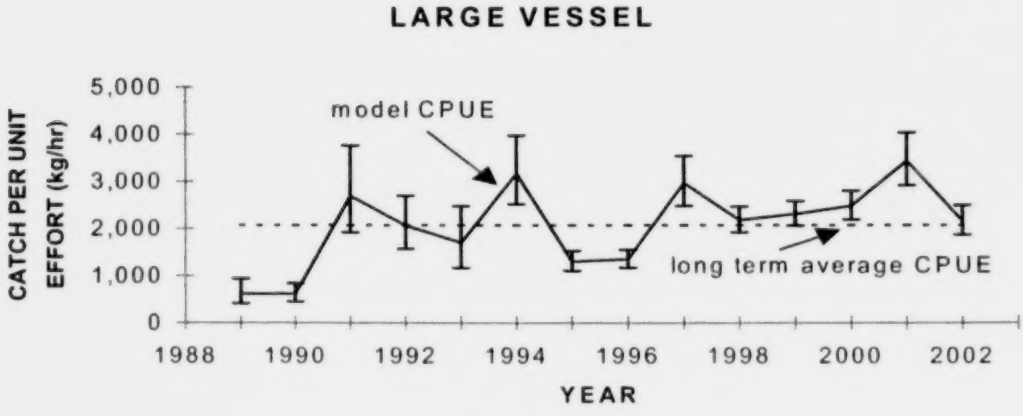
The fishery from 1988 to 1990 occurred throughout Div. 2G, which, during that period, was split into two management zones, north and south of 60^0 N. The 1991 - 1993 Management Plan combined the two zones and, up to 1997, effort concentrated primarily in the north (Fig. 18). From 1998 to 2002, more effort was deployed south of 60^0 N because of the separate quota for that area. By-catches of *P. montagui* were reported at some northwestern locations during the 1995 - 2002 period. Fishing occurred in January – February 2002, ceased for four months and resumed in July and continued until the end of the year (Fig. 19).

The overlay of number of cells accounting for 95% of the catch upon the actual catches reflects these changes in Management Plan. The number of cells increased during periods in which there was a separate quota for the southern portion of SFA 4. During 2000, the fishery was spread along the shelf edge from northern to southern 2G. Since then fishing has been in the northeastern part of 2G and at the mouth of Saglek Channel, in the south. The index of cells decreased between 2000 and 2001 and remained within the 1995 – 2000 range through 2002.



Catch per unit effort (CPUE)

The CPUE data were analyzed by multiple regression, weighted by effort, for year, month and vessel effects. The model accounted for approximately 67% of the variation in the data and indicated that the annual, standardized catch rates for 1991 – 1993 and 1998 - 2000 were similar ($P > 0.05$) to the 2002 estimate (Tables 6 & 7). The 2002 CPUE estimate was slightly above the long term average. There were no trends in the residuals around the parameter estimates (Fig. 20).

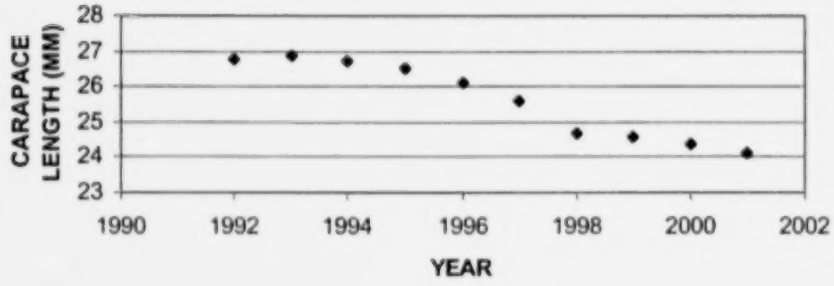


Size composition

Catch-at-length data for the 1993 - 2002 period showed variable size distributions between years (Fig. 21). Since 1992, the mean length of females and median size at sex inversion has declined. However, decreases since 1998

are thought to reflect increased fishing in southern 2G where growth rates and maturity schedules resemble those seen in the Hopedale + Cartwright area. Given the recent high and stable catch rates of primarily female shrimp in this area, it appears that a healthy spawning biomass is being maintained. The female distributions always appeared broad reflecting the contribution of more than one year class to the female component.

TRENDS IN AVERAGE CARAPACE LENGTH AMONG FEMALES TAKEN IN THE LARGE VESSEL FISHERY



RESEARCH SURVEY DATA

No research survey was conducted in this area since 1999. Therefore, no direct comparison with previous stock size estimates and stock composition is possible.

RESOURCE STATUS

The spawning stock appears healthy, as evidenced in continued high catch rates of large female shrimp and stability in catch rates. However, current status and prospects are unknown because the lack of a survey precludes evaluation of stock size, level of exploitation and future recruitment.

ASSESSMENT OF SHRIMP IN NAFO DIVISION 0B (SFA 2)

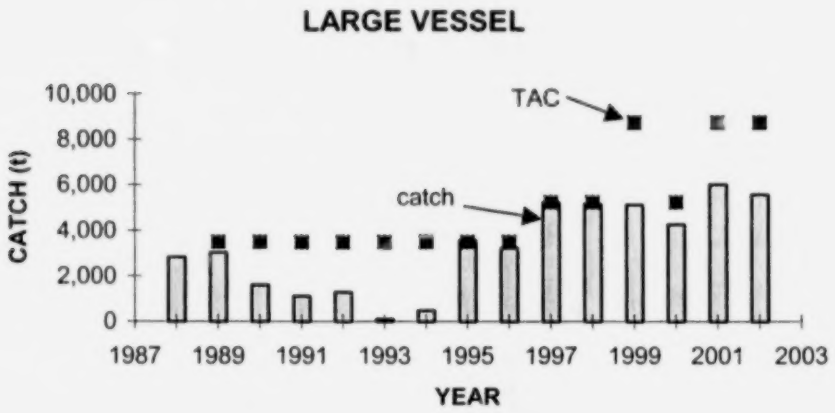
FISHERY DATA

Catch and effort

Catches of *Pandalus borealis* in Div. 0B increased from about 2,800 tons in 1988 to 3,000 tons in 1989 but subsequently declined to 100 tons in 1993. The 1994, catch was less than 500 tons; however, catches increased substantially to about 3,600 and 3,200 tons in 1995 and 1996, respectively, and to more than 5,000

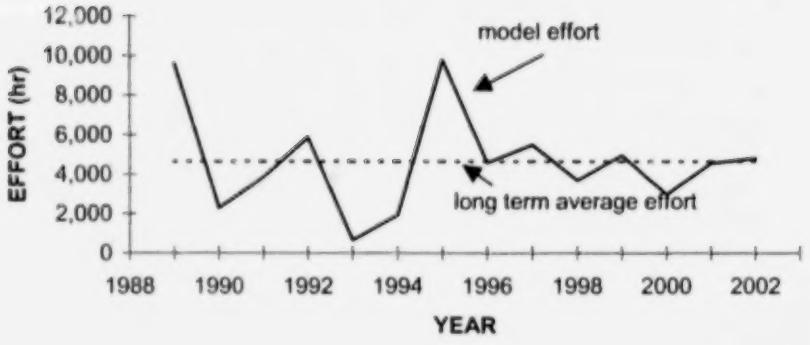
tons each year from 1997 to 1999. Approximately 6,000 tons were caught during 2001 while preliminary data indicate that 5,600 tons were taken in 2002.

Recent catches for the species have been estimated, in part, from the mixed fishery data for *P. borealis/montagui* in the area east of Resolution Island but their accuracy is questionable. *Pandalus borealis* taken in the immediately adjacent areas of SFA's 3 and 4 were included in the catches reported for SFA 2. TAC's remained at 3,500 tons from 1989 to 1996 but were increased experimentally to 5,250 tons for 1997 and 1998. In 1999, an additional 3,500 tons were provided for the area north of 63^0 N as an incentive for the offshore fleet to return to grounds not fished extensively since 1995. However, just over 100 tons were taken within this area in 1999. In 2000, the additional 3,500 tons was not included in the quota report, and accordingly the catch was not counted against the TAC for the south (5,250 tons). In 2001, the additional 3,500 tons was included in the quota report as an exploratory quota east of 63°W. Approximately 6,000 tons were taken in the south during 2001, while preliminary data indicate that 5,600 tons were taken in SFA 2 during 2002. No reliable catch statistics are available for the exploratory area.



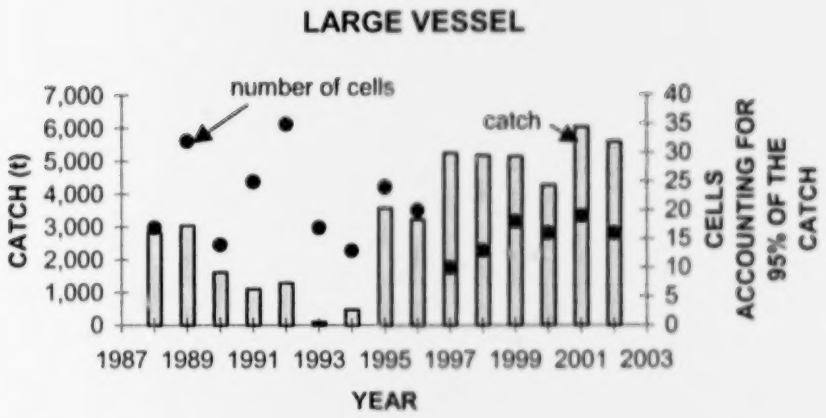
Fishing effort decreased from 1989 to 1990 and remained near the 1990 level for the next two years. Effort increased from a low in 1993 to 1995 and has since remained relatively stable near the long term average.

LARGE VESSEL



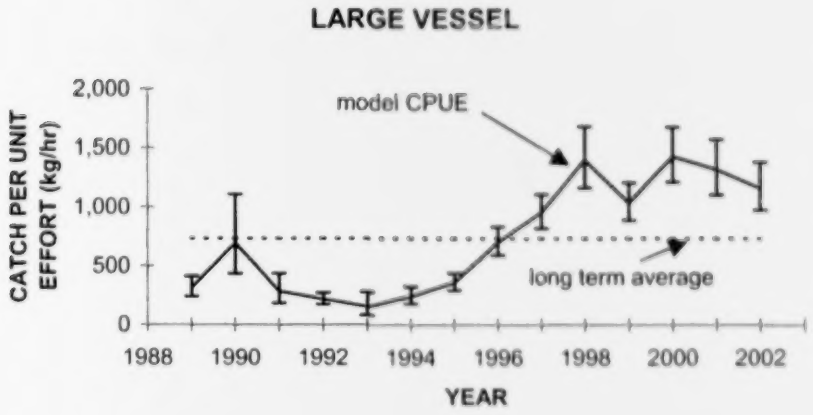
In the late 1980's, fishing effort was primarily concentrated between 64^0 and 65^0 N whereas, during the 1990 - 1994 period, proportionately more was distributed south of 64^0 N. The areas fished extensively in the southwest from 1995 to 2000 reflect the targeting of *Pandalus borealis* and *P. montagui* concentrations east of Resolution Island. Most of the effort since 1996 occurred south of 63^0 N (Fig. 22). The large vessels begin fishing during the summer and continued until late fall (Fig. 23).

The amount of area accounted for in 95% of the catch appears about average. However, the index provides confounded results in 0B because of the data reporting problems (both in terms of reporting catches against SFA quota and the mixture of *Pandalus borealis* with *P. montagui*) and the frequent changes in quota. The distribution of shrimp appears to be patchy and as new patches of shrimp were discovered, the fishery changed both in area accounted for in catching allocations and locations fished.



Catch per unit effort (CPUE)

The standardized annual CPUE showed an overall decline from 1990 to 1993. Catch rates increased sharply from 1993 to 1998 after which they remained stable. The model was standardized for year, month and vessel effects with effort weighting and accounted for 77% of the variance in data (Table 10). The 1997 – 2001 indices were statistically similar ($P>0.05$) to the 2002 estimate. All estimates prior to 1997 were significantly lower than the 2002 estimate ($P<0.05$). Figure 24 indicates that there were no clear trends in the scatter of residuals around various parameter estimates.

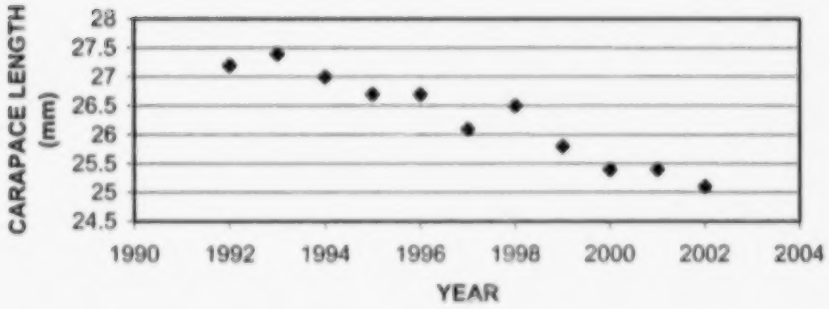


Size composition

Catches in most years were composed primarily of large, female shrimp (Fig. 25) with a modal length of 24-27 mm CL. The mean size of females and the median size at sex change declined after 1993. The percent males <22 mm in the

catches, as well as the overall catch rates of male and female components, increased with the southward shift in fishing effort. As seen in the southern areas, the female distributions appear wider than the 2000 distribution. The former probably consists of more than one year class. Once again, the average size of females has been decreasing since 1993.

TRENDS IN AVERAGE CARAPACE LENGTH AMONG FEMALES TAKEN IN THE LARGE VESSEL FISHERY



RESOURCE STATUS

Although shrimp concentrations in the northeast are elusive, as evidenced by the low catches in recent years, from the area north of 63^0 N, those adjacent to eastern Resolution Island have persisted since first fished in 1995. However, the population structure is uncertain throughout Div. 0B and distribution is unknown for much of the year. Therefore, the current status of this resource remains uncertain.

The fishery shifted to the southwest, east of Resolution Island, after 1994 and the CPUE and sampling data are not considered to be representative of stock conditions. The index of area fished is also confounded by the elusive nature of the stocks. Patches of shrimp may be present, however, the fishing crews may not always find them. If a crew can fill their quota in a patch, there may not be an incentive to search for other patches. The mixed fishery for *Pandalus borealis/ montagui* confounds the assessment and the lack of knowledge on the distribution and abundance/biomass of both species will persist in the absence of a time series of research trawl surveys. Prospects are unknown.

REFERENCES

Allen, J.A., 1959. On the biology of *Pandalus borealis* Kroyer, with reference to a population off the Northumberland coast. J. mar. biol. Ass. 38: 89 – 220.

Brodie, W. 1996. A description of the 1995 fall groundfish survey in Division 2J3KLMNO. NAFO SCR. Doc. 96/27, Serial No. N2700. 7p.

DFO, 2000. Northern Shrimp (*Pandalus borealis*) - Div. 0B to 3K. DFO Science, Stock Status Report C2-05 (2000).

Evans, G.T., D.G. Parsons, P.J. Veitch and D.C. Orr, 2000. A local-influence method of estimating biomass from trawl surveys, with Monte Carlo confidence intervals. J. Northw. Atl. Fish. Sci. 27: 133 – 138.

Golden Software, Inc. 2002. Surfer Version 8.0. contouring and 3D surface mapping for scientists and engineers. Golden Colorado. U.S.A.

McCallum, B.R. and S.J. Walsh. 1996. Groundfish survey trawls used at the Northwest Atlantic Fisheries Centre, 1971 – present. NAFO SCR Doc. 96/50. Serial No. N2726. 18p.

McCrary, J.A. 1971. Sternal spines as a characteristic for differentiating between females of some Pandalidae. J. Fish. Res. Bd. Can.., 28: 98 – 100.

Rasmussen, B. 1953. On the geographical variation in growth and sexual development of the Deep Sea Prawn (*Pandalus borealis*, Kr.). Norweg. Fish. And Mar. invest. Rep., 10 (3): 1-160.

Swain, D.P. and R. Morin. 1996. Relationsips between geographic distribution and abundance of American Plaice (*Hippoglossoides platessoides*) in the southern Gulf of St. Lawrence. Can. J. Fish. Aquat. Sci. Vol 53: 106 – 119.

Skúladóttir, U. 1997. The Icelandic shrimp fishery (*Pandalus borealis* Kr.) at the Flemish Cap in 1993 – 1997. NAFO SCR Doc. 97/85 Serial No. N2931 30p.

TABLE 1. NORTHERN SHRIMP LARGE VESSEL (>500 t) SHRIMP FISHERY DATA FOR HAWKE CHANNEL + 3K (SFA 6), 1977 - 2002.

YEAR	[1] TAC (t)	[2] FLEET CATCH (t)	[3] PERCENT CATCH OBSERVED	UNSTANDARDIZED CPUE (KG/HR)	CPUE INDEX	[4] EFFORT (HR)	STANDARDIZED RELATIVE CPUE	STANDARDIZED MODELLED CPUE	EFFORT (HRS)
1977		1							
1978	1,300								
1979	2,250	5							
1980	1,350								
1981	1,350	135							
1982	1,350	1							
1983	1,350								
1984	1,350								
1985	1,350								
1986	2,050								
1987	3,000	1,845							
1988	3,000	7,849							
1989	5,600	6,662	5	869	0.58	7,665	0.67	716	9,303
1990	5,600	5,598	5	699	0.46	8,003	0.49	525	10,661
1991	4,301	5,500	8	467	0.31	11,774	0.39	420	13,103
1992	7,565	6,609	7	661	0.44	9,997	0.40	431	15,324
1993	9,180	8,035	25	931	0.62	8,632	0.60	645	12,448
1994	11,050	10,978	94	1,441	0.95	7,620	0.69	743	14,769
1995	11,050	10,914	58	1,992	1.32	5,480	0.97	1,039	10,501
1996	11,050	10,923	90	1,993	1.32	5,481	0.98	1,049	10,413
1997	15,335	14,954	79	1,895	1.26	7,890	1.22	1,311	11,410
1998	16,360	16,264	77	1,813	1.20	8,972	1.05	1,131	14,380
1999	17,603	17,587	93	1,763	1.17	9,974	1.03	1,108	15,879
2000	19,387	20,615	96	2,060	1.36	10,009	1.21	1,303	15,817
2001	20,103	19,894	76	2,036	1.35	9,769	1.16	1,252	15,887
2002	20,103	20,102	48	1,509	1.00	13,321	1.00	1,076	18,684

[1] HISTORICAL TAC'S APPLIED AS FOLLOWS:

1978 TO 1985 - INCLUDES 500 TON EXPLORATORY TAC FOR DIVISION 3K;

1986 TO 1988 - HAWKE CHANNEL, ST. ANTHONY BASIN;

1989 TO 1991 - HAWKE CHANNEL, ST. ANTHONY BASIN, EAST ST. ANTHONY AND FUNK ISLAND DEEP;

1992 - INCLUDES 1700 TONS EXPLORATORY;

1993 - INCLUDES 3400 TONS EXPLORATORY;

1994 - 1999 - ALL AREAS COMBINED.

TAC'S FROM 1987 TO 1990, INCLUSIVE, ARE FOR THE FISHING SEASON MAY 1 TO APRIL 30, MAKING 1986 A 16 MONTH YEAR (JAN.1, 1986 - APRIL 30, 1987) AND 1991 AN 8 MONTH YEAR (MAY 1 - DEC. 31).

TAC'S AFTER 1996 MAY INCLUDE TRANSFERS OF QUOTA FROM OTHER SECTORS.

[2] CATCH (TONS) IN CALENDAR YEAR AS REPORTED IN LOG BOOKS FOR 1977, ECONOMIC ASSESSMENT OF THE NORTHERN SHRIMP FISHERY FROM 1978 TO 1989 AND YEAR-END QUOTA REPORTS, THEREAFTER.

[3] PERCENT CATCH OBSERVED IN CALENDAR YEAR AS REPORTED IN STANDARDIZED OBSERVER DATA CPUE DATASET

[4] EFFORT CALCULATED (CATCH/CPUE) FROM LARGE VESSEL OBSERVER DATA, SINGLE TRAWL, NO WINDOWS.

TABLE 2. NORTHERN SHRIMP SMALL VESSEL (<500 t; loa<100') SHRIMP FISHERY DATA FOR HAWKE CHANNEL + 3K (SFA 6), 1997 - 2002.

YEAR	[1] TAC (t)	[2] FLEET CATCH (t)	UNSTANDARDIZED CPUE (KG/HR)	CPUE INDEX	[3] EFFORT (HR)	STANDARDIZED RELATIVE CPUE	MODELLED CPUE	EFFORT (HRS)
1997	7,765	6,064						
1998	29,840	30,073	211	1.01	142,768	1.62	360	83,648
1999	41,029	33,673	215	1.03	156,630	1.66	368	91,488
2000	41,521	42,651	249	1.20	171,454	1.87	415	102,880
2001	41,520	32,736	239	1.15	137,000	1.87	416	78,742
2002	41,529	39,841	208	1.00	191,104	1.67	370	107,716

[1] TAC'S FOR SMALL VESSEL FISHERY BEGAN IN 1997 - ALL AREA COMBINED

[2] THE NORTHERN SHRIMP CATCHES FROM YEAR-END QUOTA REPORTS.

[3] EFFORT CALCULATED (CATCH/ CPUE) FROM SMALL VESSEL (<500 t; <100') LOGBOOK DATA.

Table 3. Multiplicative, year, month, vessel, area model for CPUE in Hawke Channel + 3K, 1989 – 2002, weighted by effort (large vessel (>500 t), single trawl, no windows, observer data).

The GLM Procedure
Class Level Information

Class	Levels	Values
year	14	1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002
month	12	1 2 3 4 5 7 8 9 10 11 12 99
CFV	14	
area	7	67 68 69 90 91 92 999

Number of observations 1228

Dependent Variable: lncpue
Weight: wfactor

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	43	14968.68998	348.10907	55.32	<.0001
Error	1184	7450.42473	6.29259		
Corrected Total	1227	22419.11471			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.667675	34.27970	2.508503	7.317752

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	13	5181.803969	398.600305	63.34	<.0001
month	11	6335.951685	575.995608	91.54	<.0001
CFV	13	2976.630129	228.971548	36.39	<.0001
area	6	474.304199	79.050700	12.56	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	13	2770.014453	213.078035	33.86	<.0001
month	11	3975.032604	361.366600	57.43	<.0001
CFV	13	2999.029618	230.694586	36.66	<.0001
area	6	474.304199	79.050700	12.56	<.0001

Parameter		Estimate	Standard Error	t Value	Pr > |t|
Intercept		6.991860523 B	0.05809606	120.35	<.0001
year	1989	-0.407074599 B	0.13950431	-2.92	0.0036
year	1990	-0.717301129 B	0.14428501	-4.97	<.0001
year	1991	-0.941218945 B	0.09362754	-10.05	<.0001
year	1992	-0.914152479 B	0.11028328	-8.29	<.0001
year	1993	-0.510908990 B	0.07235036	-7.06	<.0001
year	1994	-0.369777176 B	0.04820808	-7.67	<.0001
year	1995	-0.034547460 B	0.05864041	-0.59	0.5559
year	1996	-0.025300940 B	0.05231573	-0.48	0.6287
year	1997	0.197309037 B	0.04863003	4.06	<.0001
year	1998	0.049950861 B	0.04613608	1.08	0.2792
year	1999	0.029042677 B	0.04414109	0.66	0.5107
year	2000	0.191781489 B	0.04249005	4.51	<.0001
year	2001	0.151798695 B	0.04449049	3.41	0.0007
year	2002	0.000000000 B			

year	lncpue LSMEAN	95% Confidence Limits	
1989	6.573825	6.303775	6.843875
1990	6.263598	5.989904	6.537293
1991	6.039681	5.864696	6.214666
1992	6.066747	5.853751	6.279744
1993	6.469991	6.352441	6.587541
1994	6.611122	6.521896	6.700348
1995	6.946352	6.833706	7.058999
1996	6.955599	6.853708	7.057489
1997	7.178209	7.086590	7.269828
1998	7.030850	6.942045	7.119656
1999	7.009942	6.925978	7.093907
2000	7.172681	7.093597	7.251765
2001	7.132698	7.046011	7.219385
2002	6.980900	6.891309	7.070490

Table 4. Multiplicative, year, month, area model for CPUE in Hawke Channel + 3K, 1998 – 2002, weighted by effort (small vessel (<500 t; <100'), logbook data).

The GLM Procedure
Class Level Information

Class	Levels	Values
year	5	1998 1999 2000 2001 2002
month	8	4 5 7 8 9 10 11 99
area	7	67 68 80 90 91 92 100

Number of observations 228

Dependent Variable: lncpue
Weight: wfactor

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	4594.501990	270.264823	10.57	<.0001
Error	210	5371.470412	25.578431		
Corrected Total	227	9965.972402			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.461019	85.55204	5.057512	5.911621

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	4	1916.163553	479.040888	18.73	<.0001
month	7	549.111085	78.444441	3.07	0.0043
area	6	2129.227353	354.871225	13.87	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	4	1074.547824	268.636956	10.50	<.0001
month	7	1044.410136	149.201448	5.83	<.0001
area	6	2129.227353	354.871225	13.87	<.0001

Parameter		Estimate	Standard Error	t Value	Pr > |t|
Intercept		5.944380729 B	0.02905725	204.57	<.0001
year	1998	-0.028402000 B	0.03043821	-0.93	0.3518
year	1999	-0.004830651 B	0.03000472	-0.16	0.8723
year	2000	0.109995905 B	0.02793537	3.94	0.0001
year	2001	0.110869091 B	0.02681681	4.13	<.0001
year	2002	0.000000000 B	.	.	.

year	lncpue LSMEAN	95% Confidence Limits	
1998	5.885512	5.816103	5.954921
1999	5.909083	5.837280	5.980886
2000	6.023910	5.956061	6.091758
2001	6.024783	5.953866	6.095700
2002	5.913914	5.845246	5.982582

TABLE 5. NORTHERN SHRIMP LARGE VESSEL (>500 t) FISHERY DATA FOR HOPEDALE & CARTWRIGHT CHANNELS (SFA 5), 1977 - 2002.

YEAR	[1] TAC (t)	[2] FLEET CATCH (t)	[3] PERCENT CATCH OBSERVED	UNSTANDARDIZED CPUE (KG/HR)	UNSTANDARDIZED CPUE INDEX	[4] EFFORT (HR)	STANDARDIZED RELATIVE CPUE	STANDARDIZED MODELLED CPUE	STANDARDIZED EFFORT (HRS)
1977		2,686							
1978	5,300	3,630							
1979	4,000	3,727							
1980	4,800	4,108	52	475	0.16	8,653	0.41	758	5,416
1981	4,800	3,449	45	432	0.15	7,986	0.45	817	4,221
1982	4,800	1,983	34	402	0.14	4,930	0.41	747	2,656
1983	4,800	1,000							
1984	4,200	1,002	29	365	0.13	2,748	0.34	624	1,607
1985	3,570	1,689	13	346			0.34	623	2,710
1986	4,400	4,826	10	588	0.20	8,214	0.32	592	8,148
1987	4,800	5,956	2	747	0.26	7,970	0.28	509	11,711
1988	4,800	7,838	7	732	0.25	10,708	0.41	761	10,300
1989	6,000	5,985	38	717	0.25	8,348	0.46	853	7,020
1990	6,000	5,360	79	663	0.23	8,084	0.45	821	6,532
1991	6,375	6,118	79	569	0.20	10,756	0.40	738	8,287
1992	6,375	6,315	75	752	0.26	8,402	0.38	691	9,142
1993	6,375	5,719	97	695	0.24	8,232	0.41	761	7,516
1994	7,650	7,499	97	827	0.28	9,065	0.44	812	9,233
1995	7,650	7,616	63	1,538	0.53	4,952	0.57	1,044	7,297
1996	7,650	7,383	96	1,959	0.67	3,769	0.73	1,331	5,549
1997	15,300	15,103	99	1,623	0.56	9,307	0.83	1,515	9,972
1998	14,929	14,827	87	2,173	0.75	6,824	0.79	1,444	10,268
1999	15,136	14,720	100	2,189	0.75	6,725	0.89	1,632	9,017
2000	14,050	14,645	97	2,333	0.80	6,277	0.94	1,730	8,466
2001	14,694	15,036	96	2,543	0.87	5,913	1.01	1,847	8,141
2002	14,118	14,669	84	2,907	1.00	5,046	1.00	1,834	7,998

[1] TAC'S FROM 1987 TO 1990, INCLUSIVE ARE FOR THE FISHING SEASON MAY 1 TO APRIL 30, MAKING 1986 A 16 MONTH YEAR (JAN. 1, 1986 - APRIL 30, 1987) AND 1991 AN 8 MONTH YEAR (MAY 1 - DEC. 31). TAC'S AFTER 1996 MAY INCLUDE TRANSFERS FROM OTHER SECTORS.

[2] CATCH (TONS) IN CALENDAR YEAR AS REPORTED IN LOG BOOKS FOR 1977, ECONOMIC ASSESSMENT OF THE NORTHERN SHRIMP FISHERY FROM 1978 TO 1989 AND YEAR-END QUOTA REPORTS, THEREAFTER.

[3] PERCENT CATCH OBSERVED IN CALENDAR YEAR AS REPORTED IN STANDARDIZED OBSERVER DATA CPUE DATASET

[4] EFFORT CALCULATED (CATCH/CPUE) FROM LARGE VESSEL OBSERVER DATA, SINGLE TRAWL, NO WINDOWS.

Table 6. Multiplicative, year, month vessel, area model for CPUE in Hopedale - Cartwright Channels, 1980 – 2002, weighted by effort (large vessel (=>500 t), single trawl, no windows, Observer data).

The GLM Procedure
Class Level Information

Class	Levels	Values
year	19	1980 1981 1982 1984 1985 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002
month	12	1 2 3 4 5 7 8 9 10 11 12 13
CFV	25	
area	4	52 53 54 99

Number of observations 1458

Dependent Variable: lncpue
Weight: wfactor

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	59	47459.86110	804.40443	79.65	<.0001
Error	1398	14118.17162	10.09884		
Corrected Total	1457	61578.03272			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.770727	46.18952	3.177866	6.880060

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	21	37172.09757	1770.09988	175.28	<.0001
month	11	5980.64916	543.69538	53.84	<.0001
CFV	24	4078.56387	169.94016	16.83	<.0001
area	3	228.55050	76.18350	7.54	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	21	6872.608208	327.267058	32.41	<.0001
month	11	3472.376656	315.670605	31.26	<.0001
CFV	24	4078.594153	169.941423	16.83	<.0001
area	3	228.550499	76.183500	7.54	<.0001

Parameter		Estimate	Standard Error	t Value	Pr > |t|
Intercept		7.270663843 B	0.12354389	58.85	<.0001
year	1980	-0.882998952 B	0.08768027	-10.07	<.0001
year	1981	-0.808385057 B	0.09950279	-8.12	<.0001
year	1982	-0.898647728 B	0.11511290	-7.81	<.0001
year	1984	-1.078727559 B	0.13782935	-7.83	<.0001
year	1985	-1.079372831 B	0.14919858	-7.23	<.0001
year	1986	-1.130267894 B	0.42692311	-2.65	0.0082
year	1987	-1.282611598 B	0.27872098	-4.60	<.0001
year	1988	-0.879659322 B	0.15763137	-5.58	<.0001
year	1989	-0.765959727 B	0.08168974	-9.38	<.0001
year	1990	-0.804213860 B	0.07452759	-10.79	<.0001
year	1991	-0.909979492 B	0.07179246	-12.68	<.0001
year	1992	-0.976412531 B	0.07088968	-13.77	<.0001
year	1993	-0.879796384 B	0.06830700	-12.88	<.0001
year	1994	-0.814552405 B	0.06495172	-12.54	<.0001
year	1995	-0.563713277 B	0.07824743	-7.20	<.0001
year	1996	-0.320910524 B	0.07432284	-4.32	<.0001
year	1997	-0.191387368 B	0.06348599	-3.01	0.0026
year	1998	-0.239141303 B	0.06651307	-3.60	0.0003
year	1999	-0.116436811 B	0.06568464	-1.77	0.0765
year	2000	-0.058417889 B	0.06485672	-0.90	0.3679
year	2001	0.007024491 B	0.06550144	0.11	0.9146
year	2002	0.000000000 B	.	.	.

Table 6. (Continued)

year	lncpue LSMEAN	95% Confidence Limits	
1980	6.631270	6.499810	6.762730
1981	6.705884	6.546534	6.865233
1982	6.615621	6.420497	6.810745
1984	6.435541	6.186367	6.684716
1985	6.434896	6.161423	6.708369
1986	6.384001	5.581724	7.186278
1987	6.231657	5.696319	6.766996
1988	6.634610	6.348269	6.920950
1989	6.748309	6.623429	6.873189
1990	6.710055	6.614132	6.805978
1991	6.604289	6.512976	6.695602
1992	6.537856	6.442451	6.633262
1993	6.634472	6.540930	6.728015
1994	6.699716	6.610898	6.788535
1995	6.950556	6.820489	7.080623
1996	7.193358	7.072458	7.314258
1997	7.322881	7.234891	7.410872
1998	7.275128	7.172601	7.377654
1999	7.397832	7.300048	7.495616
2000	7.455851	7.356966	7.554735
2001	7.521293	7.420926	7.621661
2002	7.514269	7.400963	7.627574

TABLE 7. NORTHERN SHRIMP LARGE VESSEL (>500 t) FISHERY DATA FOR DIV. 2G (SFA 4), 1979 - 2002.

YEAR	TAC [1] (t)	FLEET CATCH [2] (t)	PERCENT CATCH [3] OBSERVED	UNSTANDARDIZED CPUE (KG/HR)	CPUE INDEX	EFFORT [4] (HR)	STANDARDIZED RELATIVE CPUE	MODELLED CPUE	EFFORT (HRS)
1979	500	3							
1980	500	<1							
1981	500	2							
1982	500	5							
1983	500	30							
1984	500								
1985	500								
1986	500	2							
1987	500	7							
1988	500	1,083							
1989	2580	3,842	2	352	0.14	10,926	0.29	625	6,147
1990	2580	2,945	10	719	0.29	4,096	0.29	623	4,725
1991	2635	2,561	24	2,010	0.82	1,274	1.24	2,697	950
1992	2635	2,706	51	2,133	0.87	1,268	0.95	2,067	1,309
1993	2735	2,723	17	2,161	0.88	1,260	0.79	1,709	1,594
1994	4000	3,982	55	3,690	1.50	1,079	1.46	3,175	1,254
1995	5200	5,104	45	1,408	0.57	3,625	0.60	1,309	3,900
1996	5200	5,160	63	1,332	0.54	3,873	0.63	1,358	3,799
1997	5200	5,216	64	3,098	1.26	1,684	1.37	2,973	1,754
1998	8008	7,918	76	2,359	0.96	3,357	1.01	2,183	3,626
1999	8008	7,836	94	2,333	0.95	3,358	1.07	2,313	3,387
2000	8008	8,048	90	2,594	1.05	3,103	1.14	2,484	3,241
2001	8008	7,991	64	3,870	1.57	2,065	1.59	3,440	2,323
2002	8008	7,879	60	2,462	1.00	3,201	1.00	2,169	3,632

1 TAC'S FROM 1987 TO 1990, INCLUSIVE ARE FOR THE FISHING SEASON MAY 1 TO APRIL 30, MAKING 1986 A 16 MONTH YEAR (JAN.1, 1986 - APRIL 30, 1987) AND 1991 AN 8 MONTH YEAR (MAY 1 - DEC. 31). TAC'S AFTER 1996 INCLUDE TRANSFERS FROM OTHER SECTORS.

2 CATCH (TONS) AS REPORTED IN: LOGBOOKS FOR 1979, ECONOMIC ASSESSMENT OF THE NORTHERN SHRIMP FISHERY FROM 1980 TO 1989 AND FROM YEAR-END QUOTA REPORTS AND/OR LOGBOOKS, THEREAFTER.

3 PERCENT CATCH OBSERVED IN CALENDAR YEAR AS REPORTED IN STANDARDIZED OBSERVER DATA CPUE DATASET.

4 EFFORT CALCULATED (CATCH/CPUE) FROM LARGE VESSEL OBSERVER DATA, SINGLE TRAWL, NO WINDOWS.

Table 8. Multiplicative, year, month, vessel, area model for CPUE in Division 2G, 1989 – 2002, weighted by effort (large vessel (>500 t), single trawl, no windows, observer data).

The GLM Procedure
Class Level Information

Class	Levels	Values
year	14	1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002
month	8	5 6 8 9 10 11 12 13
CFV	17	

Number of observations 381

Dependent Variable: lncpue
Weight: wfactor

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	36	4700.030381	130.556399	19.04	<.0001
Error	344	2358.848059	6.857116		
Corrected Total	380	7058.878440			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.665832	34.57849	2.618610	7.572943

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	13	3344.384750	257.260365	37.52	<.0001
month	7	381.217454	54.459636	7.94	<.0001
CFV	16	974.428176	60.901761	8.88	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	13	1960.637335	150.818257	21.99	<.0001
month	7	297.673583	42.524798	6.20	<.0001
CFV	16	974.428176	60.901761	8.88	<.0001

Parameter		Estimate	Standard Error	t Value	Pr > |t|
Intercept		7.737483215 B	0.11228318	68.91	<.0001
year	1989	-1.244341863 B	0.21711151	-5.73	<.0001
year	1990	-1.247286164 B	0.16487229	-7.57	<.0001
year	1991	0.217671199 B	0.18713804	1.16	0.2456
year	1992	-0.048389972 B	0.16566981	-0.29	0.7704
year	1993	-0.238688781 B	0.19622498	-1.22	0.2247
year	1994	0.380770671 B	0.12963524	2.94	0.0035
year	1995	-0.505397913 B	0.09455074	-5.35	<.0001
year	1996	-0.468295273 B	0.08787929	-5.33	<.0001
year	1997	0.315236308 B	0.11051911	2.85	0.0046
year	1998	0.006462850 B	0.08539848	0.08	0.9397
year	1999	0.064286337 B	0.08277672	0.78	0.4379
year	2000	0.135234514 B	0.07988398	1.69	0.0914
year	2001	0.461109312 B	0.09645607	4.78	<.0001
year	2002	0.000000000 B	.	.	.

year	lncpue LSMEAN	95% Confidence Limits	
1989	6.437860	6.029032	6.846689
1990	6.434916	6.130223	6.739610
1991	7.899873	7.565207	8.234540
1992	7.633812	7.365879	7.901746
1993	7.443513	7.070188	7.816839
1994	8.062973	7.835835	8.290111
1995	7.176804	7.016123	7.337486
1996	7.213907	7.073860	7.353954
1997	7.997439	7.820750	8.174127
1998	7.688665	7.563216	7.814114
1999	7.746489	7.633867	7.859110
2000	7.817437	7.693511	7.941363
2001	8.143312	7.981550	8.305073
2002	7.682202	7.539842	7.824562

TABLE 9. NORTHERN SHRIMP LARGE VESSEL (>500 t) FISHERY DATA FOR DIVISION 0B (SFA 2), 1988 - 2002.

YEAR	TAC (t)	CATCH[2] (t)	PERCENT[3] CATCH OBSERVED	UNSTANDARDIZED CPUE (KG/HR)	CPUE INDEX	EFFORT[4] (HR)	STANDARDIZED RELATIVE CPUE	STANDARDIZED MODELLED CPUE	EFFORT (HRS)
1988		2,826							
1989	3,500	3,039	11	268	0.19	11,323	0.27	316	9,604
1990	3,500	1,609	13	589	0.42	2,732	0.60	696	2,313
1991	3,485	1,107	22	288	0.20	3,850	0.25	287	3,863
1992	3,485	1,291	50	342	0.24	3,771	0.19	220	5,867
1993	3,485	106	30	173	0.12	612	0.13	156	681
1994	3,500	476	59	337	0.24	1,411	0.21	245	1,939
1995	3,500	3,564	34	541	0.38	6,594	0.31	364	9,788
1996	3,500	3,220	91	740	0.53	4,349	0.61	704	4,577
1997	5,250	5,235	100	1,061	0.76	4,932	0.82	954	5,489
1998	5,250	5,163	83	1,648	1.17	3,132	1.21	1,400	3,688
1999	8,750	5,132	96	1,205	0.86	4,257	0.89	1,036	4,955
2000	5,250	4,261	120	1,679	1.20	2,538	1.23	1,429	2,983
2001	8,750	6,023	66	1,601	1.14	3,762	1.14	1,319	4,567
2002	8,750	5,571	66	1,404	1.00	3,969	1.00	1,159	4,806

[1] TAC'S FOR 1989 AND 1990 ARE FOR THE FISHING SEASON MAY 1 TO APRIL 30 AND FOR THE CALENDAR YEAR, THEREAFTER, MAKING 1991 AN 8 MONTH YEAR (MAY 1 - DEC. 31)
TAC'S AFTER 1996 MAY INCLUDE TRANSFERS FROM OTHER SECTORS.

[2] CATCH (TONS) FOR 1988 AND 1989 AS REPORTED IN ECONOMIC ASSESSMENT OF THE NORTHERN SHRIMP FISHERY AND FROM YEAR-END QUOTA REPORTS AND/OR LOGBOOK RECORDS, THEREAFTER.

[3] PERCENT CATCH OBSERVED IN CALENDAR YEAR AS REPORTED IN STANDARDIZED OBSERVER DATA CPUE DATASET.

[4] EFFORT CALCULATED (CATCH/CPUE) FROM LARGE VESSEL OBSERVER DATA, SINGLE TRAWL, NO WINDOWS.

Table 10. Multiplicative, year, month, vessel, area model for CPUE in Division 0B, 1989 – 2002, weighted by effort (large vessel (>500 t), single trawl, no windows, observer data).

The GLM Procedure

Class Level Information

Class	Levels	Values
year	14	1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002
month	7	6 7 8 9 10 12 13
CFV	16	

Number of observations 363

Dependent Variable: lncpue
Weight: wfactor

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	34	17597.72552	517.58016	31.67	<.0001
Error	328	5361.14098	16.34494		
Corrected Total	362	22958.86651			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.766489	60.47855	4.042888	6.684829

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	13	14791.66734	1137.82056	69.61	<.0001
month	6	1162.97441	193.82907	11.86	<.0001
CFV	15	1643.08377	109.53892	6.70	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	13	7565.192507	581.937885	35.60	<.0001
month	6	1105.601481	184.266913	11.27	<.0001
CFV	15	1643.083769	109.538918	6.70	<.0001

Parameter		Estimate	Standard Error	t Value	Pr > |t|
Intercept		7.102160186 B	0.12492825	56.85	<.0001
year	1989	-1.298323025 B	0.15951935	-8.14	<.0001
year	1990	-0.510745374 B	0.25044356	-2.04	0.0422
year	1991	-1.397616397 B	0.24301639	-5.75	<.0001
year	1992	-1.661579188 B	0.13990203	-11.88	<.0001
year	1993	-2.008377915 B	0.31247303	-6.43	<.0001
year	1994	-1.552462278 B	0.16589369	-9.36	<.0001
year	1995	-1.158004251 B	0.12576042	-9.21	<.0001
year	1996	-0.499345349 B	0.11899923	-4.20	<.0001
year	1997	-0.195076728 B	0.11110593	-1.76	0.0801
year	1998	0.188808073 B	0.12297901	1.54	0.1257
year	1999	-0.112579910 B	0.11093075	-1.01	0.3109
year	2000	0.208999226 B	0.11318995	1.85	0.0657
year	2001	0.128996505 B	0.11551229	1.12	0.2649

year	lncpue LSMEAN	95% Confidence Limits	
1989	5.757156	5.486790	6.027522
1990	6.544734	6.078878	7.010590
1991	5.657863	5.231904	6.083821
1992	5.393900	5.175829	5.611970
1993	5.047101	4.453299	5.640904
1994	5.503017	5.215158	5.790876
1995	5.897475	5.702914	6.092036
1996	6.556134	6.386460	6.725808
1997	6.860402	6.709678	7.011127
1998	7.244287	7.059739	7.428836
1999	6.942899	6.790238	7.095560
2000	7.264478	7.102191	7.426766
2001	7.184476	7.007674	7.361278
2002	7.055479	6.881436	7.229523

Figure 1. Seasonal distribution of large vessel (>500 t) shrimp catches (tons) in Hawke Channel + 3K (SFA 6) during 2002. (Observer data aggregated into 10 min. squares.)

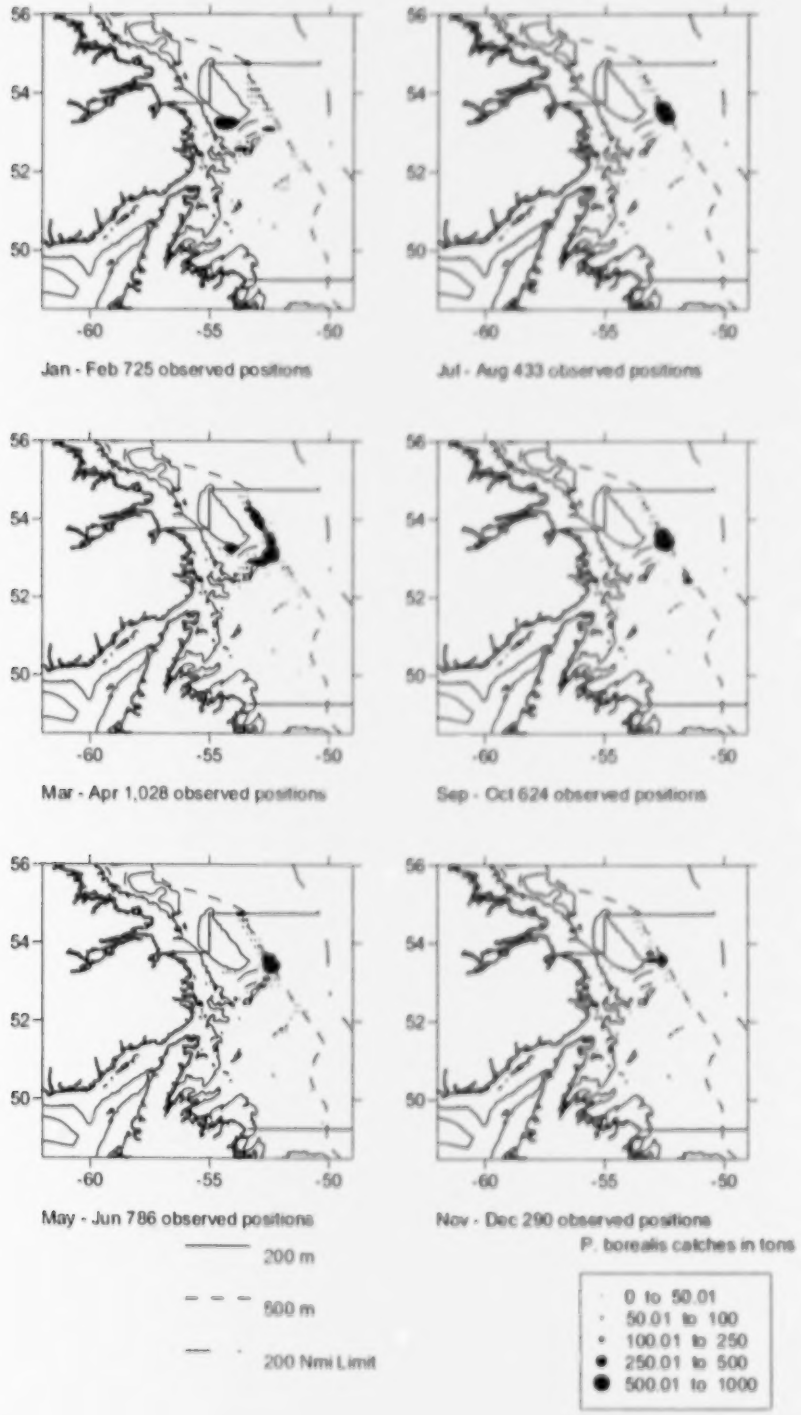


Figure 2. Seasonal distribution of small vessel (<=500 t, <100') shrimp catches (tons) in Hawke Channel + 3K (SFA 6) during 2002. (Logbook data aggregated into 10 min. squares.)

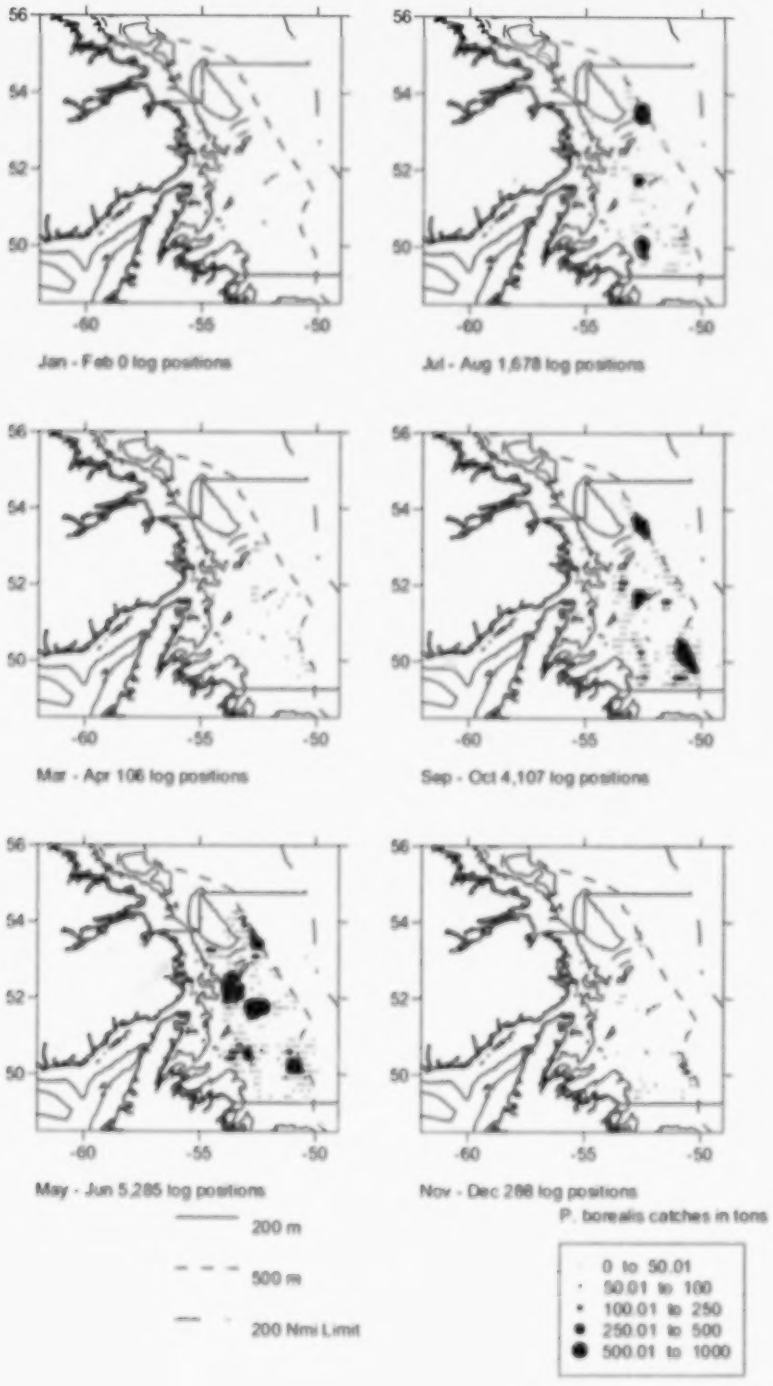


Figure 3. Distribution of large vessel (>500 t) shrimp catches in Hawke Channel + 3K (SFA 6) , 1990 – 2002. (Observer data aggregated into 10 min. squares).

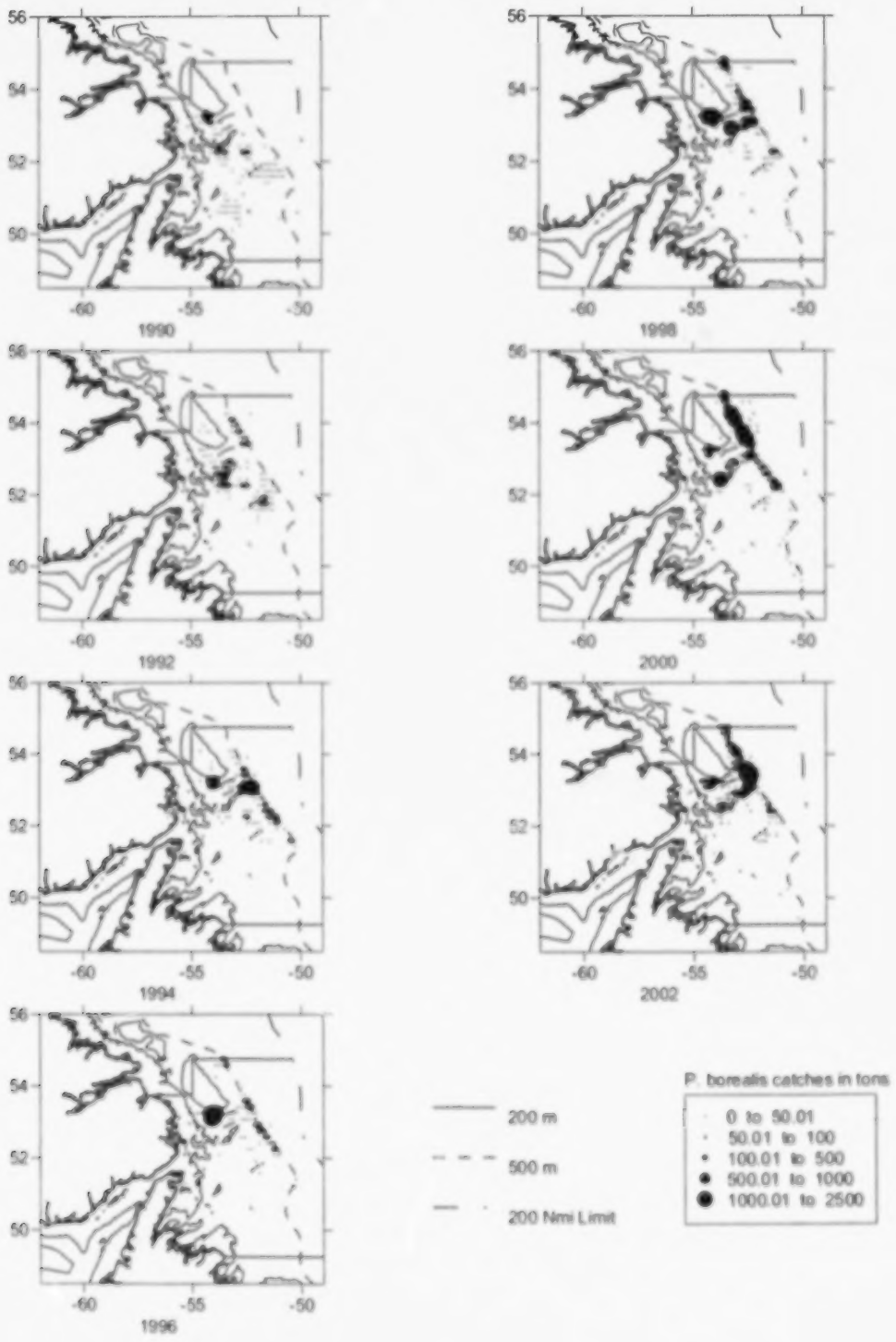


Figure 4. Distribution of small vessel (<=500 t, <100') shrimp catches in Hawke Channel + 3K (SFA 6) , 1998 – 2002. (Logbook data aggregated into 10 min. squares).

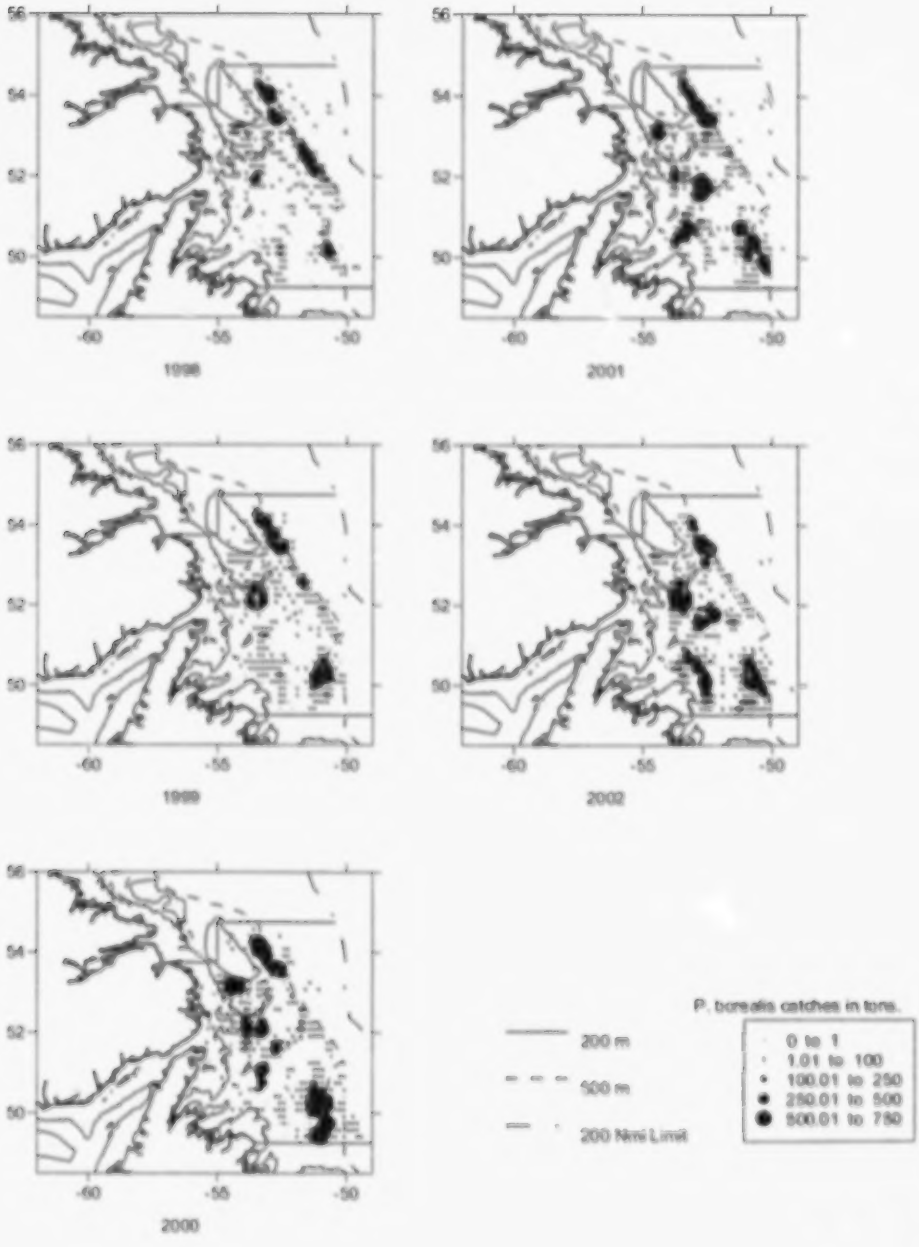


Figure 5. The distribution of residuals around estimated values for various parameters used in the Catch Per Unit Effort (CPUE) model developed for large vessels fishing in Hawke Channel + 3K (SFA 6), 1988 – 2002.

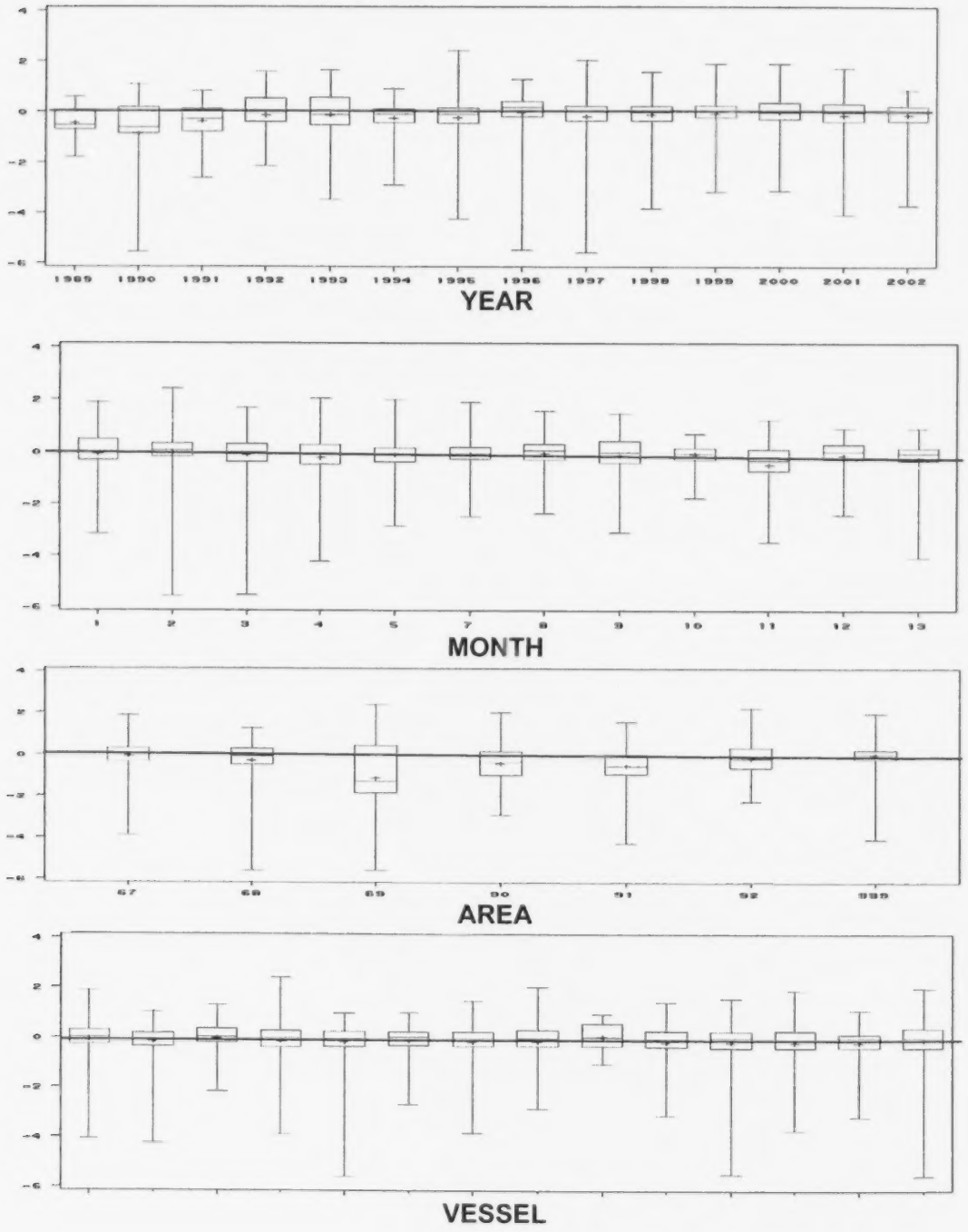


Figure 6. The distribution of residuals around estimated values for various parameters used in the Catch Per Unit Effort (CPUE) model developed for small vessels fishing in Hawke Channel + 3K (SFA 6), 1998 – 2002.

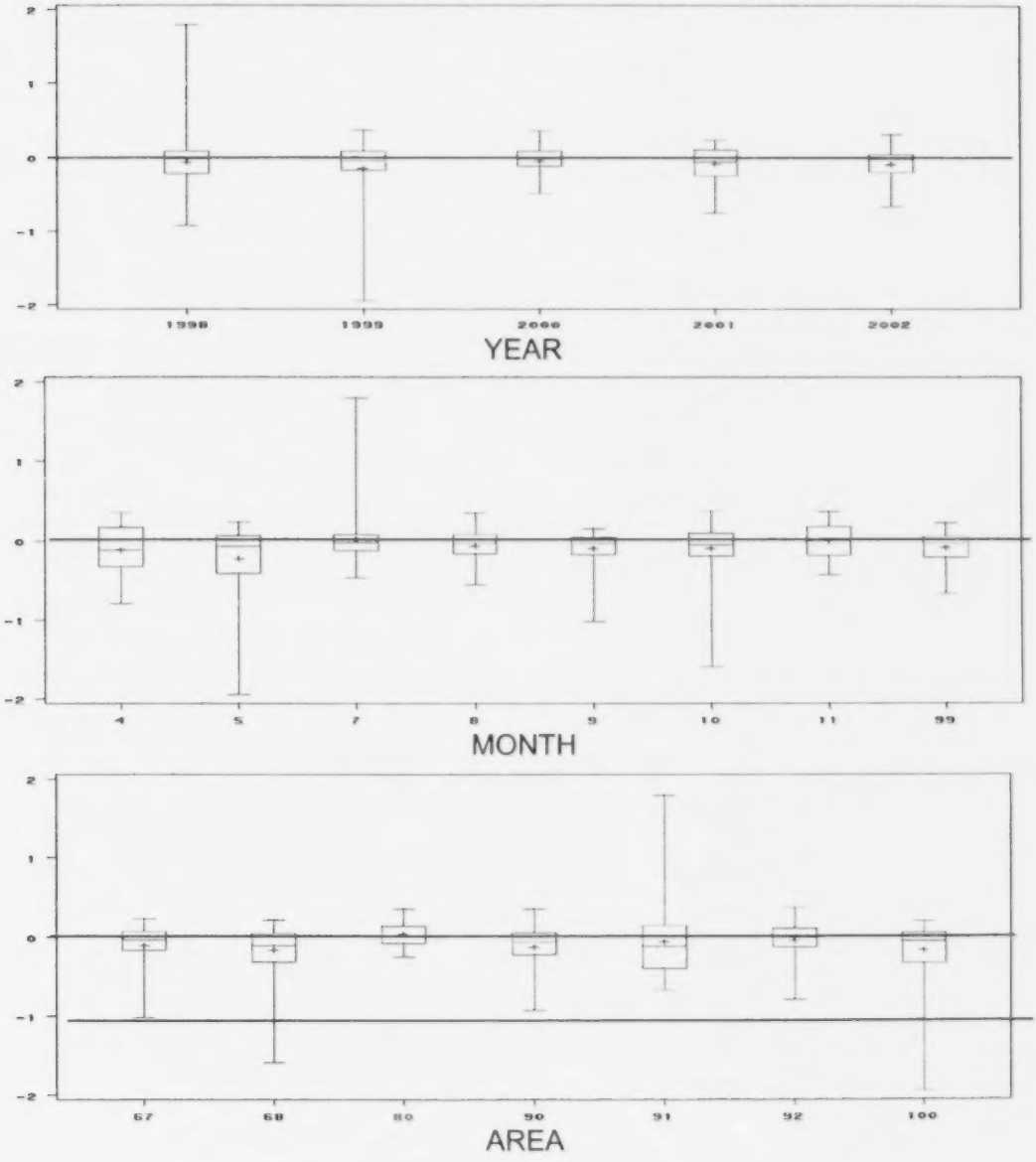


Figure 7. Standardized large vessel (>500 t) shrimp catch in number per hour (000's) in Hawke Channel + 3K (SFA 6), 1993 – 2002. Solid line = males; broken line = females.

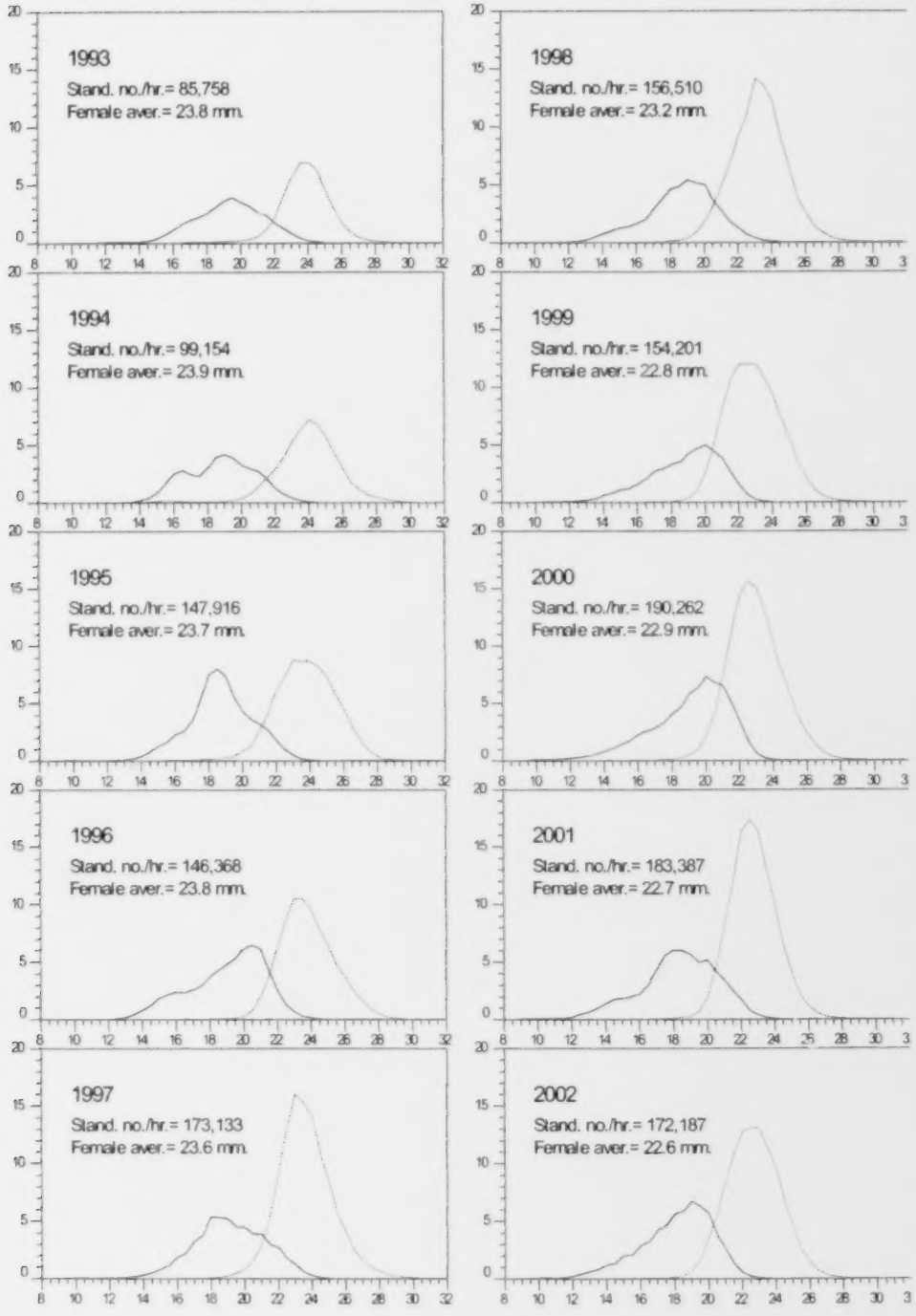


Figure 8. Standardized small vessel (<=500 t, <100') shrimp catch in number per hour (000's) in Hawke Channel + 3K (SFA 6), 2000 – 2002. Solid line = males; broken line = females.

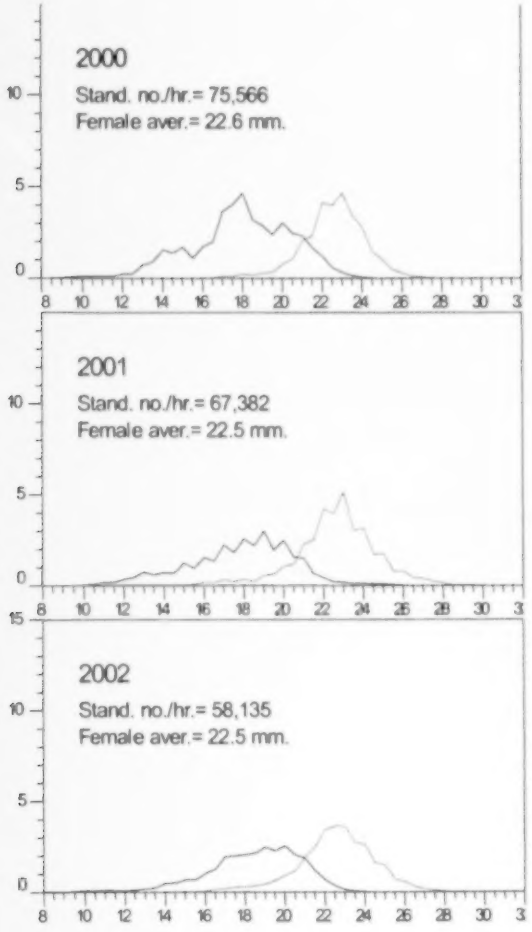


Figure 9. Catches of shrimp (*Pandalus borealis*) obtained during the 1998 – 2002 fall multi-species surveys in Hawke Channel + 3K (SFA 6) using a Campelen 1800 shrimp trawl. (Standard 15 min. tows)

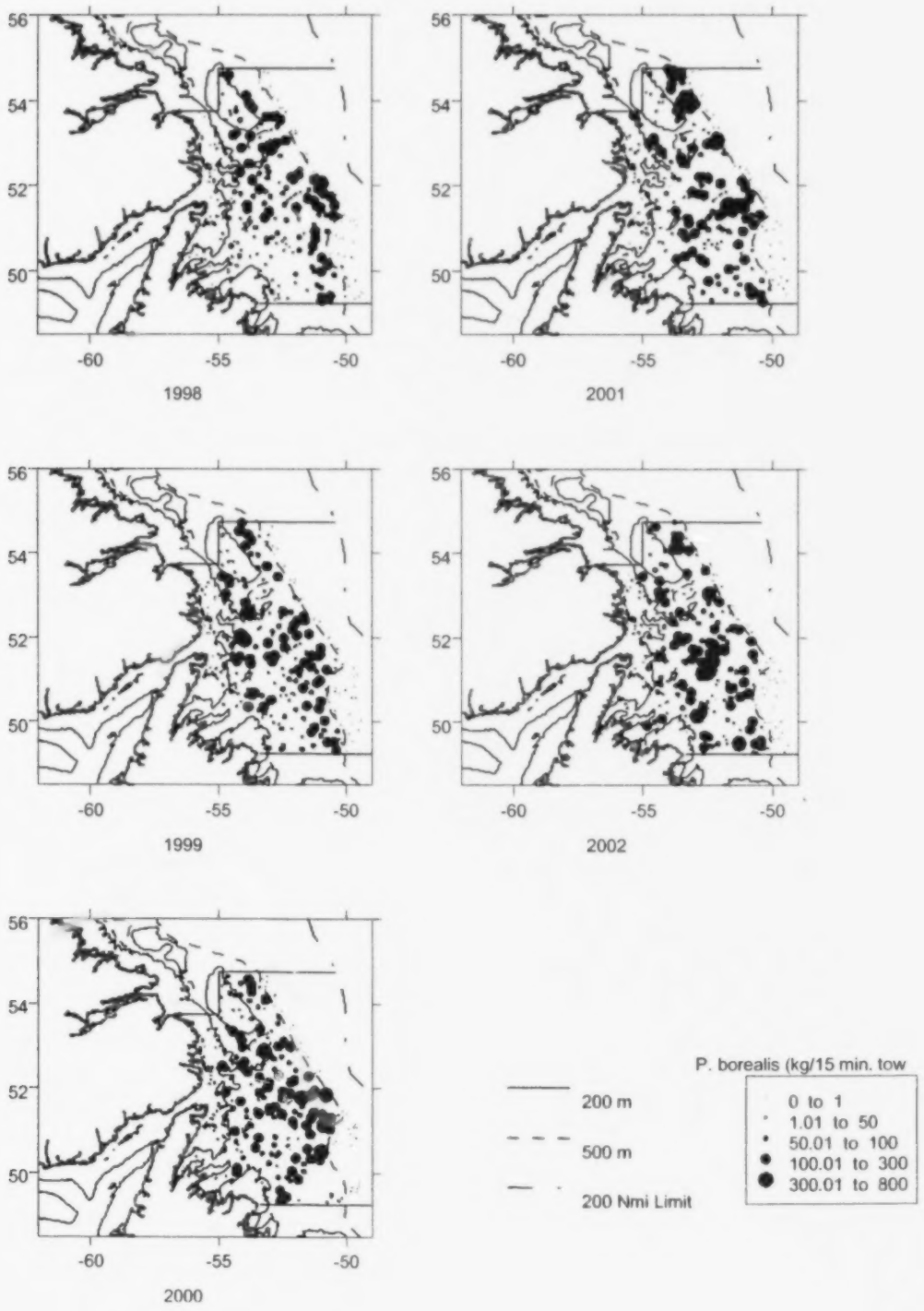


Figure 10. Ogmap densities of shrimp (*Pandalus borealis*) obtained during the 1998 – 2002 fall multi-species surveys into Hawke Channel + 3K (SFA 6) using a Campelen 1800 shrimp trawl. (Standard 15 min. tows).

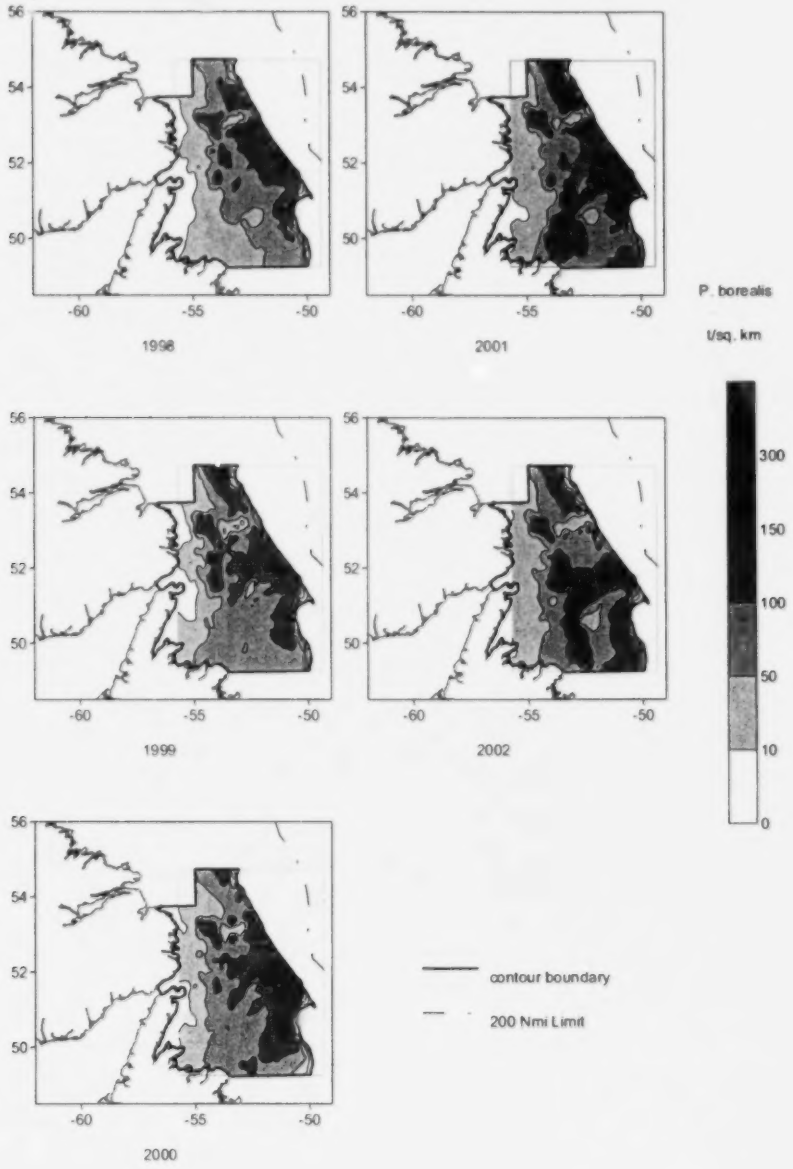


Figure 11. Abundance at length for Hawke Channel + 3K (SFA 6) estimated from Ogive MAPping (OGMAP) of research survey data, 1997 – 2002.

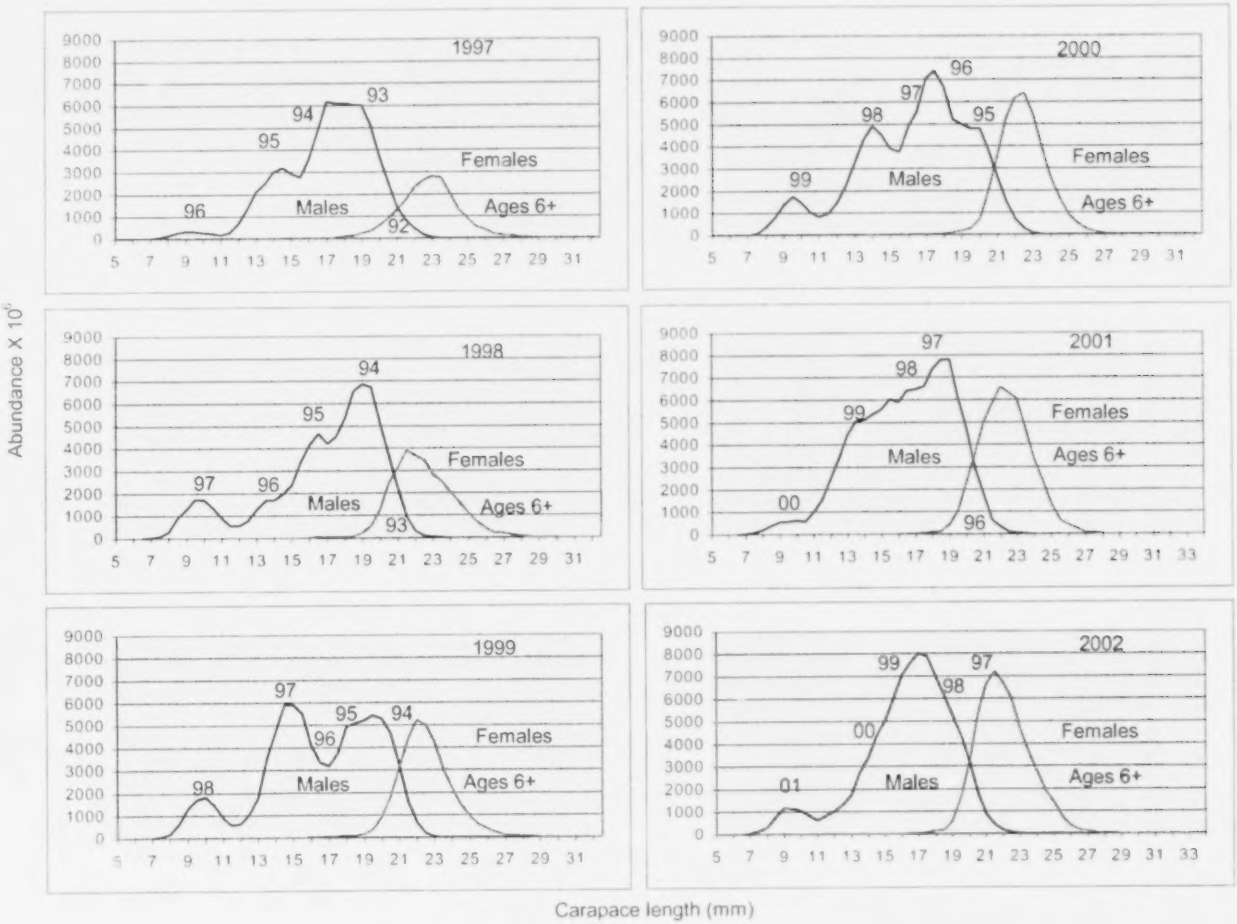


Figure 11. Abundance at length for Hawke Channel + 3K (SFA 6) estimated from Ogive MAPping (OGMAP) of research survey data, 1997 – 2002.

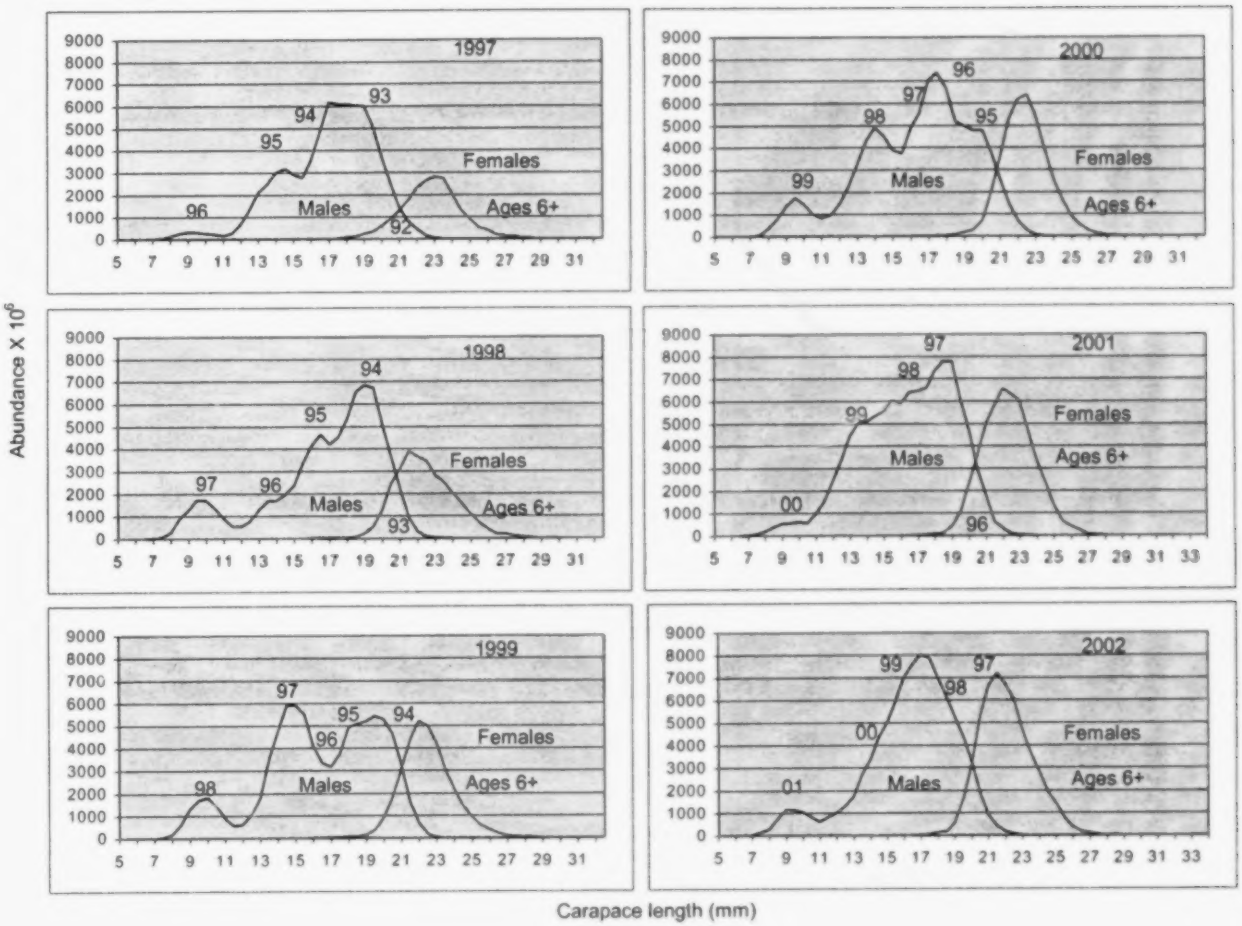


Figure 12. Distribution of large vessel (>500 t) shrimp catches in Hopedale - Cartwright Channels (SFA 5), 1990 – 2002. (Observer data aggregated into 10 min. squares).

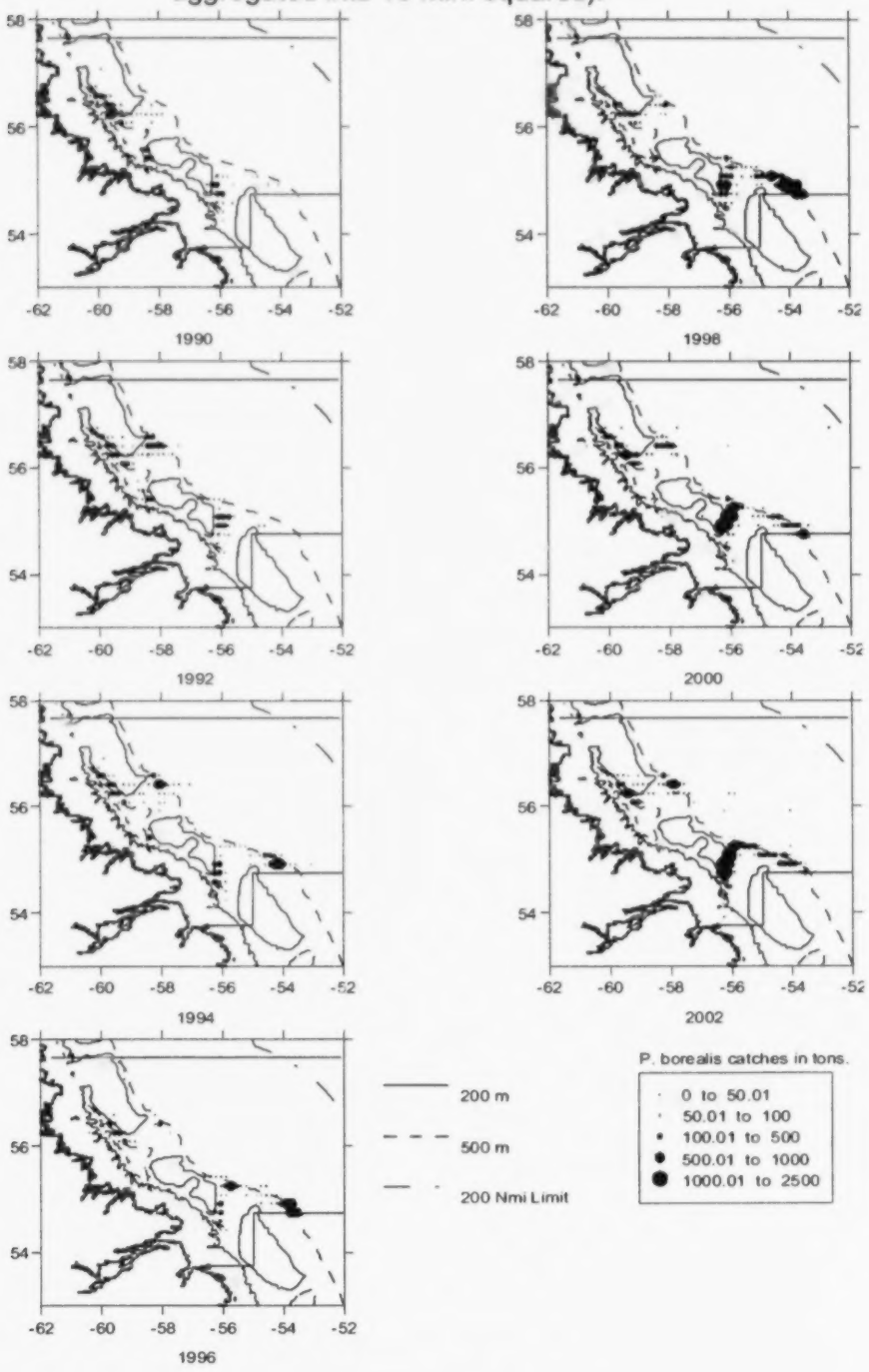


Figure 13. Seasonal distribution of large vessel (>500 t) shrimp catches (tons) in Hopedale - Cartwright Channels (SFA 5) during 2002. (Observer data aggregated into 10 min. squares.)

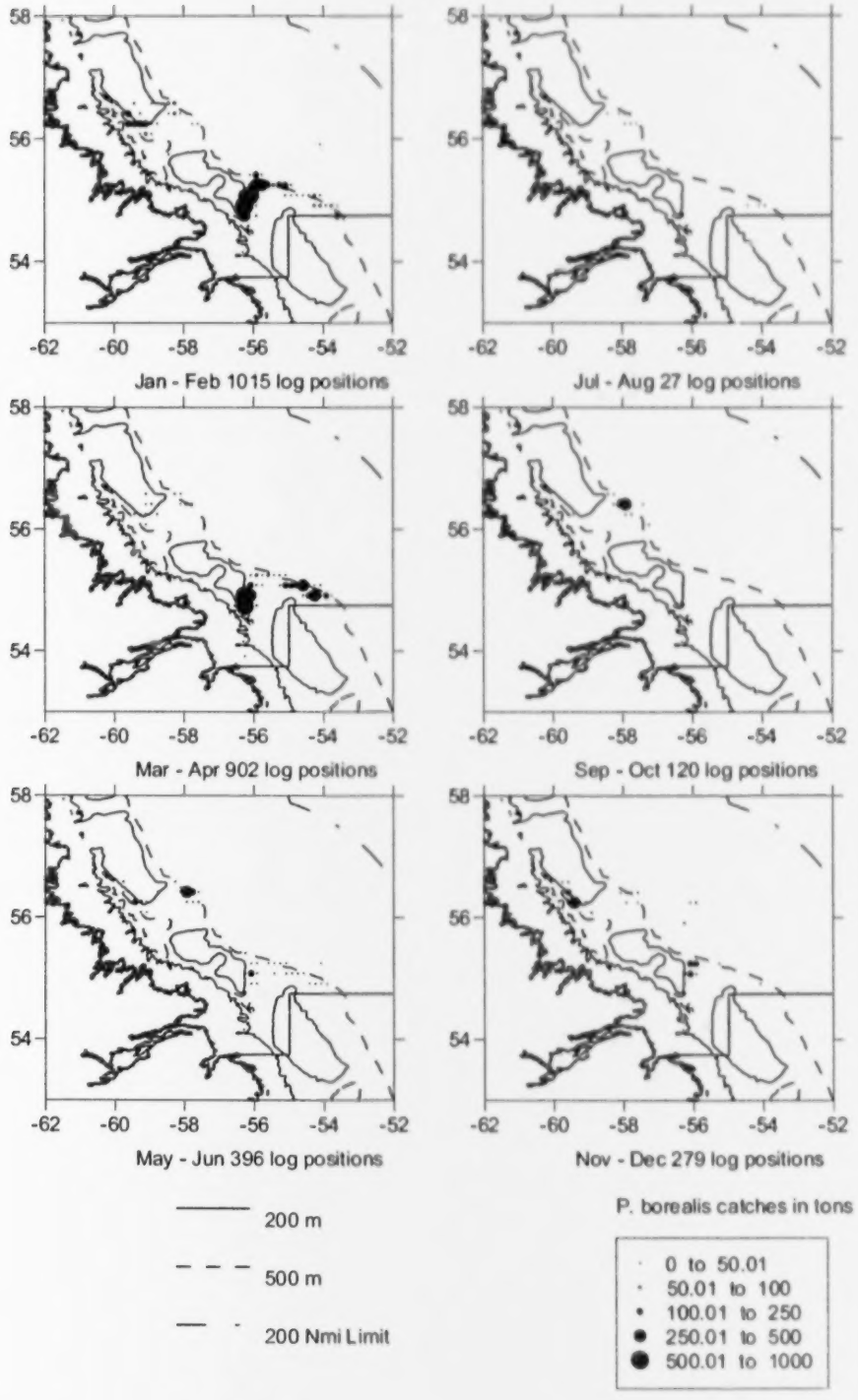
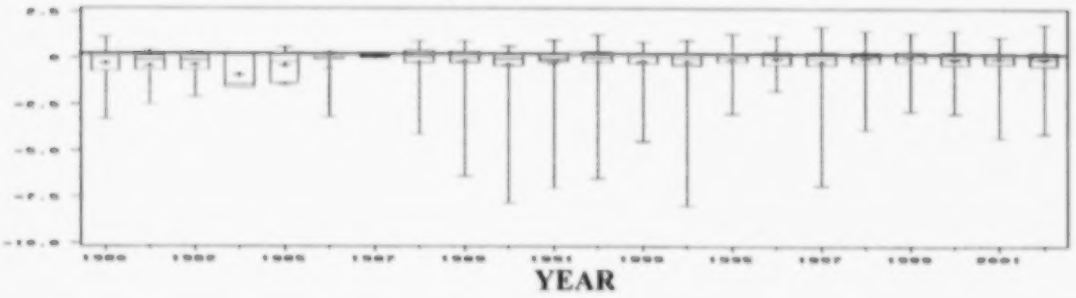
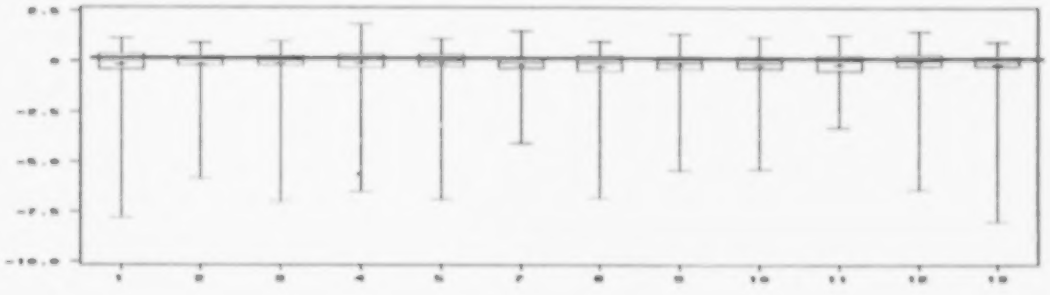


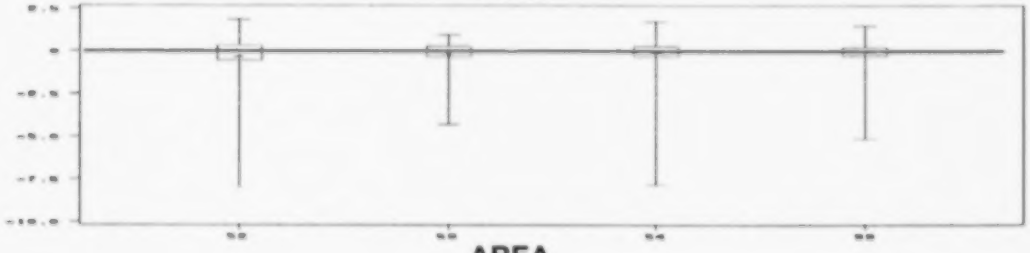
Figure 14. The distribution of residuals around estimated values for various parameters used in the Catch Per Unit Effort (CPUE) model developed for small vessels fishing in Hopedale – Cartwright Channels (SFA 5), 1980 – 2002.



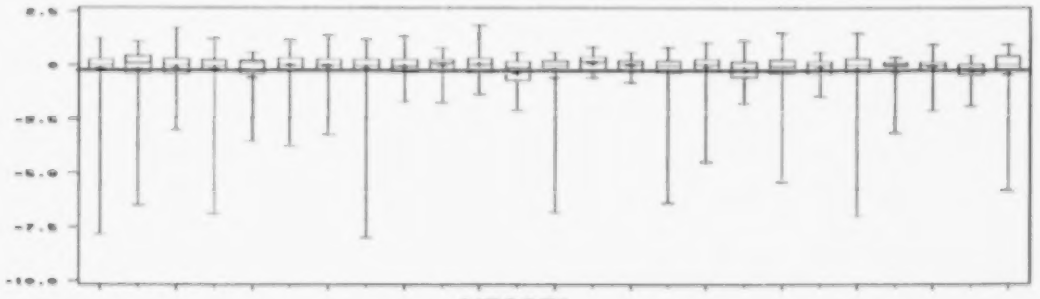
YEAR



MONTH



AREA



VESSEL

Figure 15. Standardized large vessel (>500 t) shrimp catch in number per hour (000's) in Hopedale – Cartwright Channels (SFA 5), 1993 – 2002. Solid line = males; broken line = females.

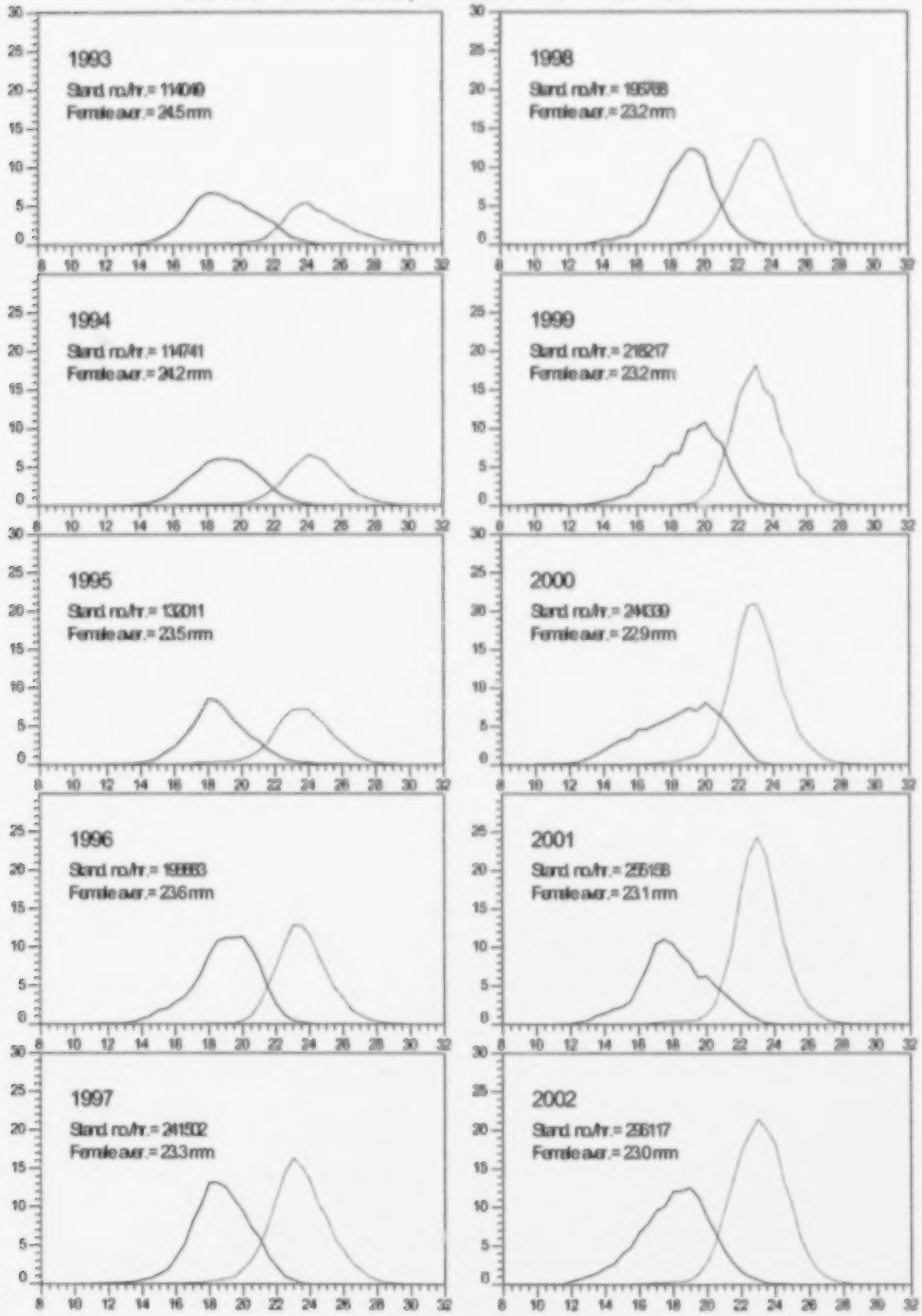


Figure 16. Catches of shrimp (*Pandalus borealis*) obtained during the 1998 – 2002 fall multi-species surveys in Hopedale – Cartwright Channels (SFA 5) using a Campelen 1800 shrimp trawl. (Standard 15 min. tows).

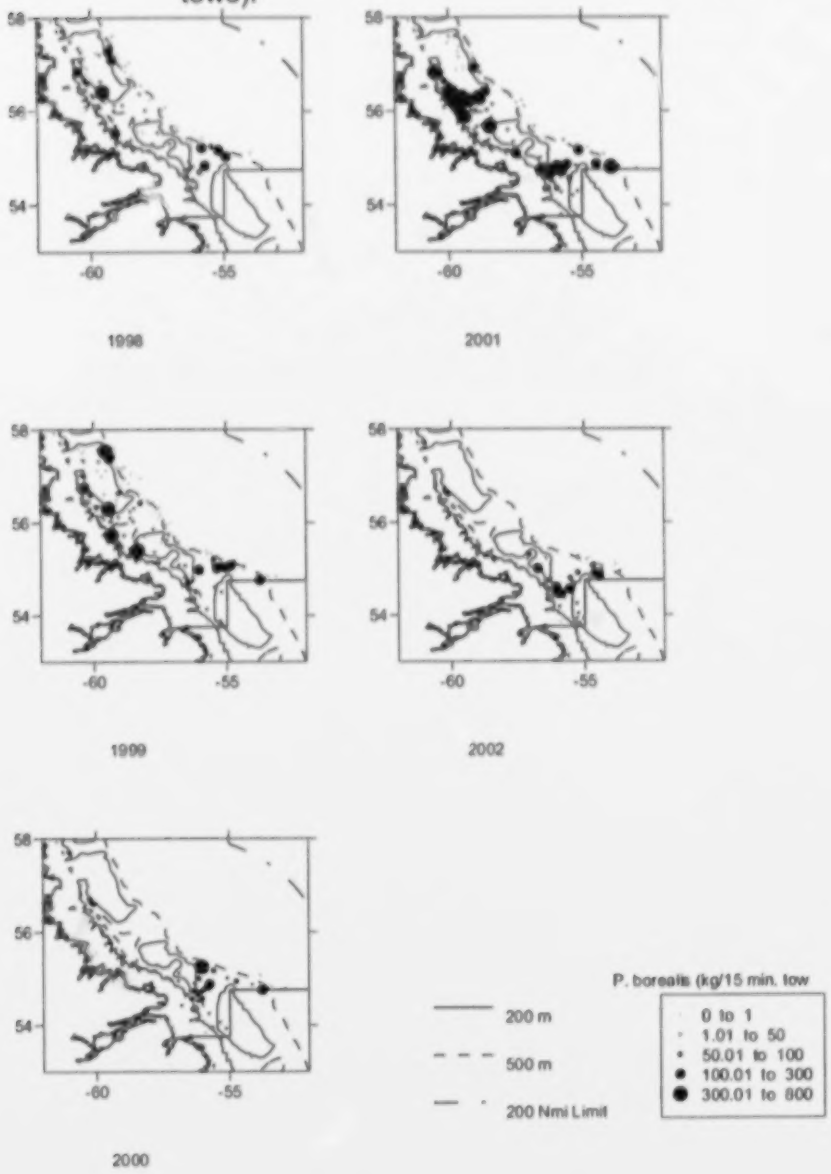


Figure 17. Ogmap densities of shrimp (*Pandalus borealis*) obtained during the 1998 – 2002 fall multi-species surveys into Hopedale – Cartwright Channels (SFA 5) using a Campelen 1800 shrimp trawl. (Standard 15 min. tows).

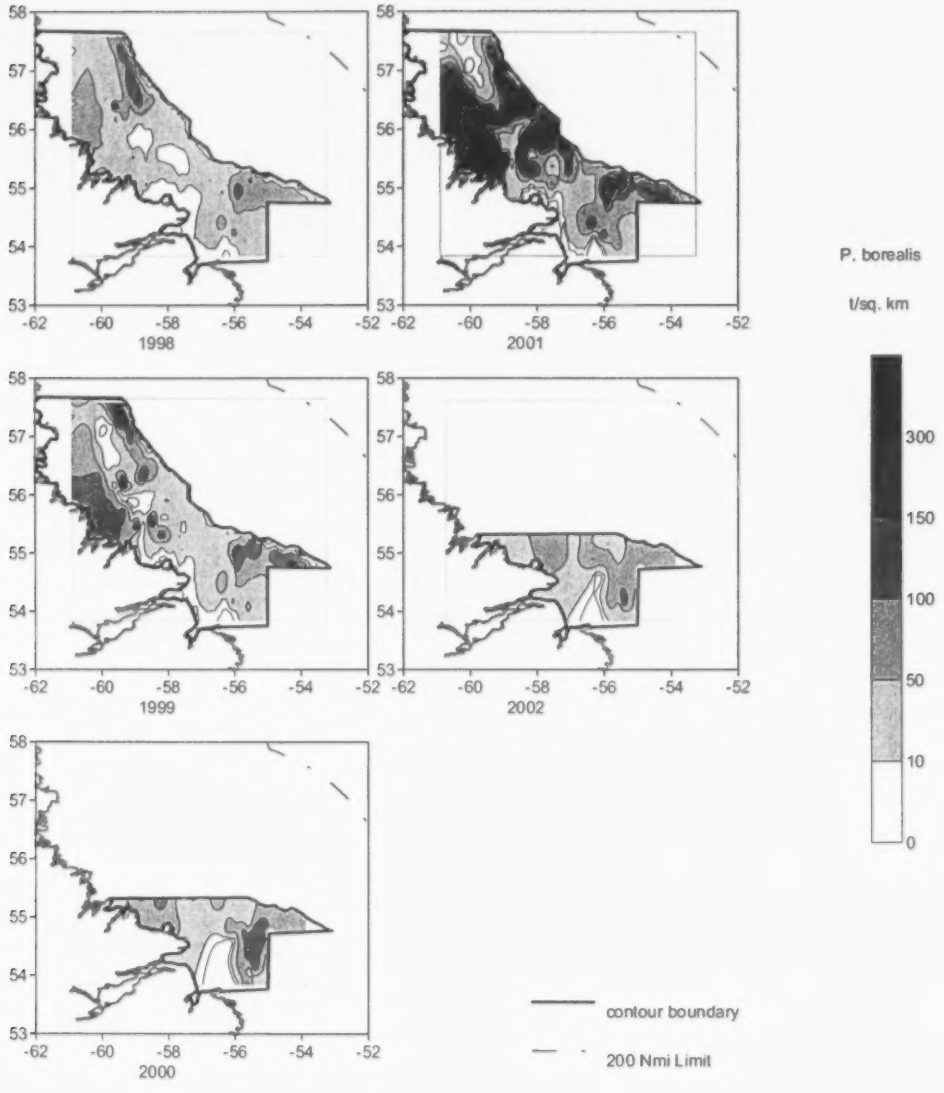


Figure 18. Distribution of large vessel (>500 t) shrimp catches in Div. 2G (SFA 4), 1990 – 2002. (Observer data aggregated into 10 min. squares).

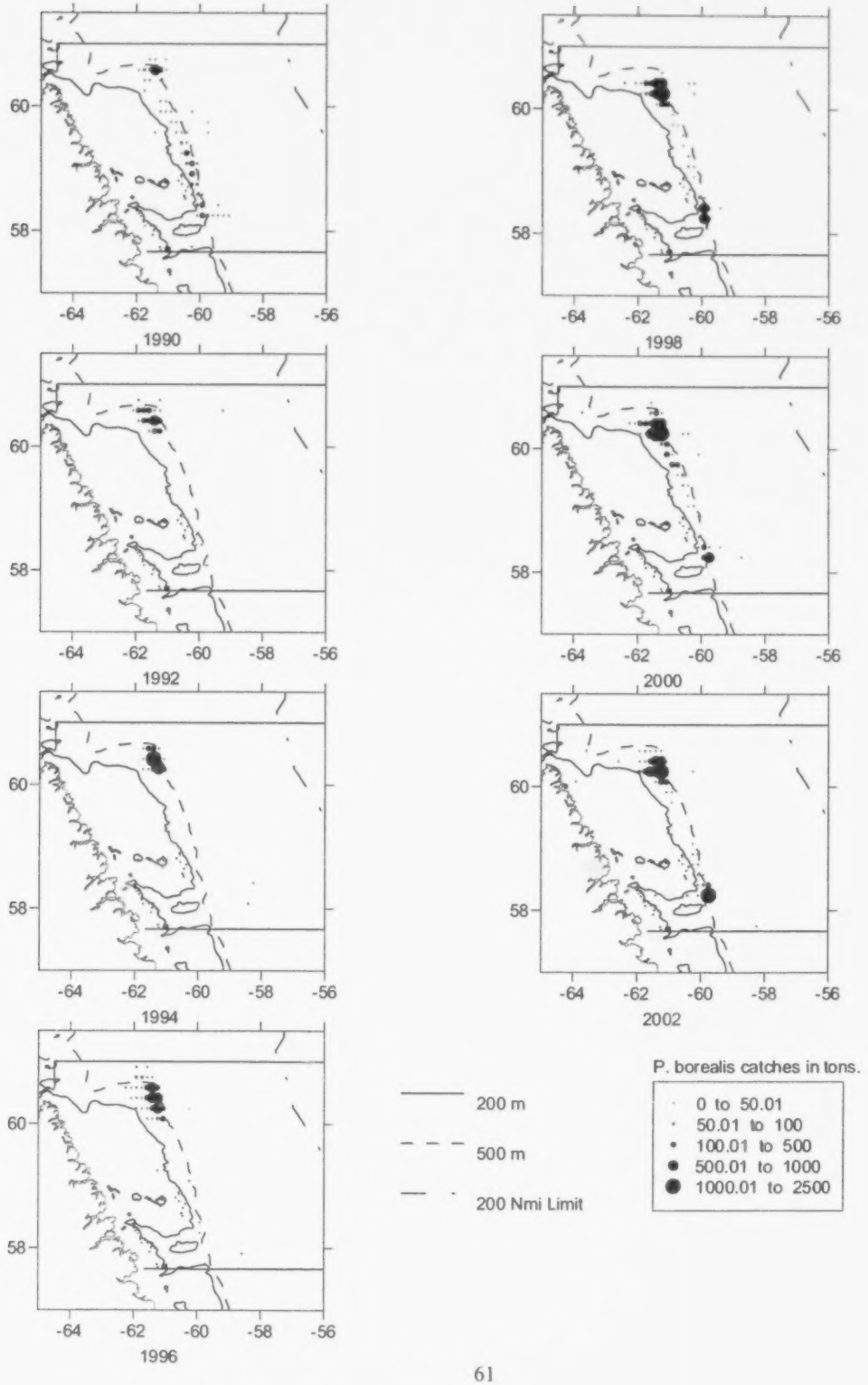


Figure 19. Seasonal distribution of large vessel (>500 t) shrimp catches (tons) in Div. 2G (SFA 4) during 2002. (Observer data aggregated into 10 min. squares.)

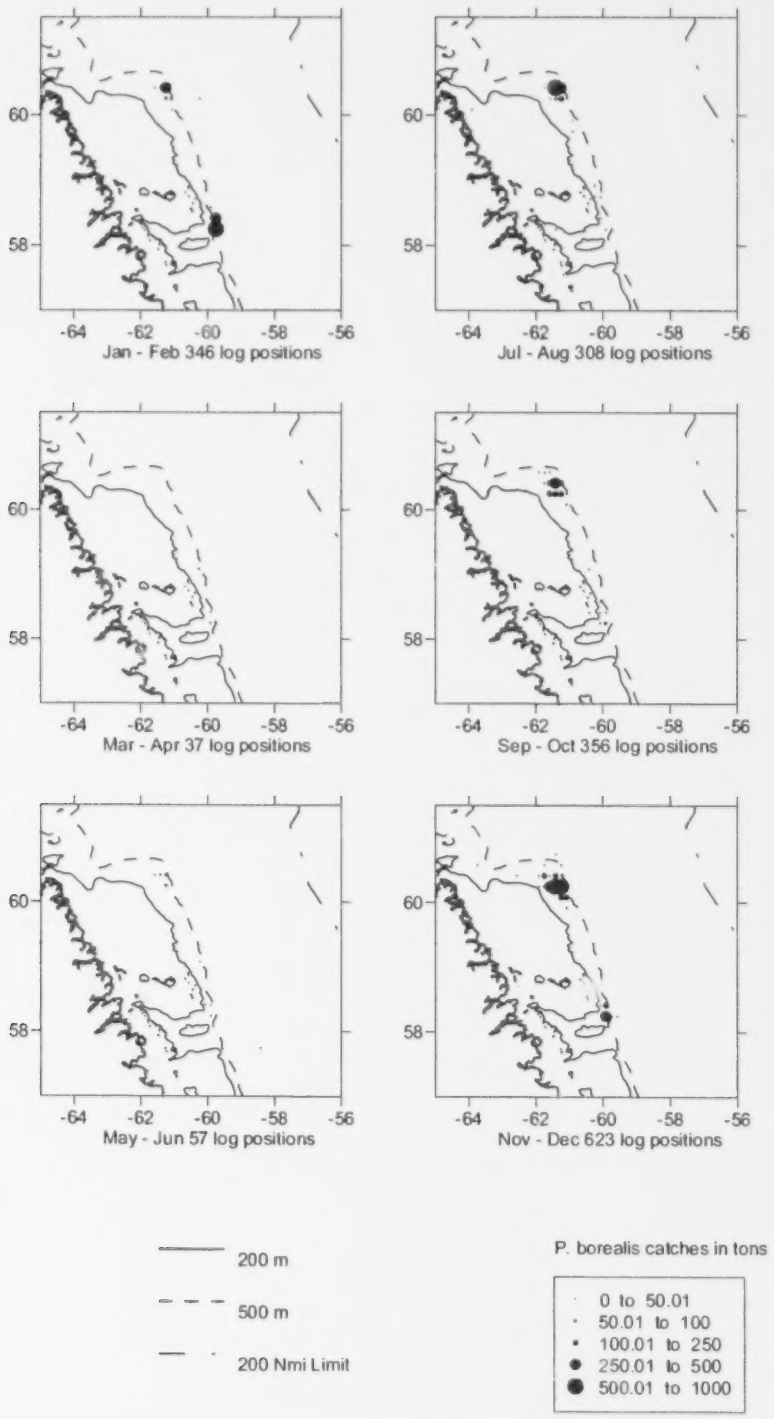


Figure 20. The distribution of residuals around estimated values for various parameters used in the Catch Per Unit Effort (CPUE) model developed for large vessels fishing in Div 2G (SFA 4), 1989 – 2002.

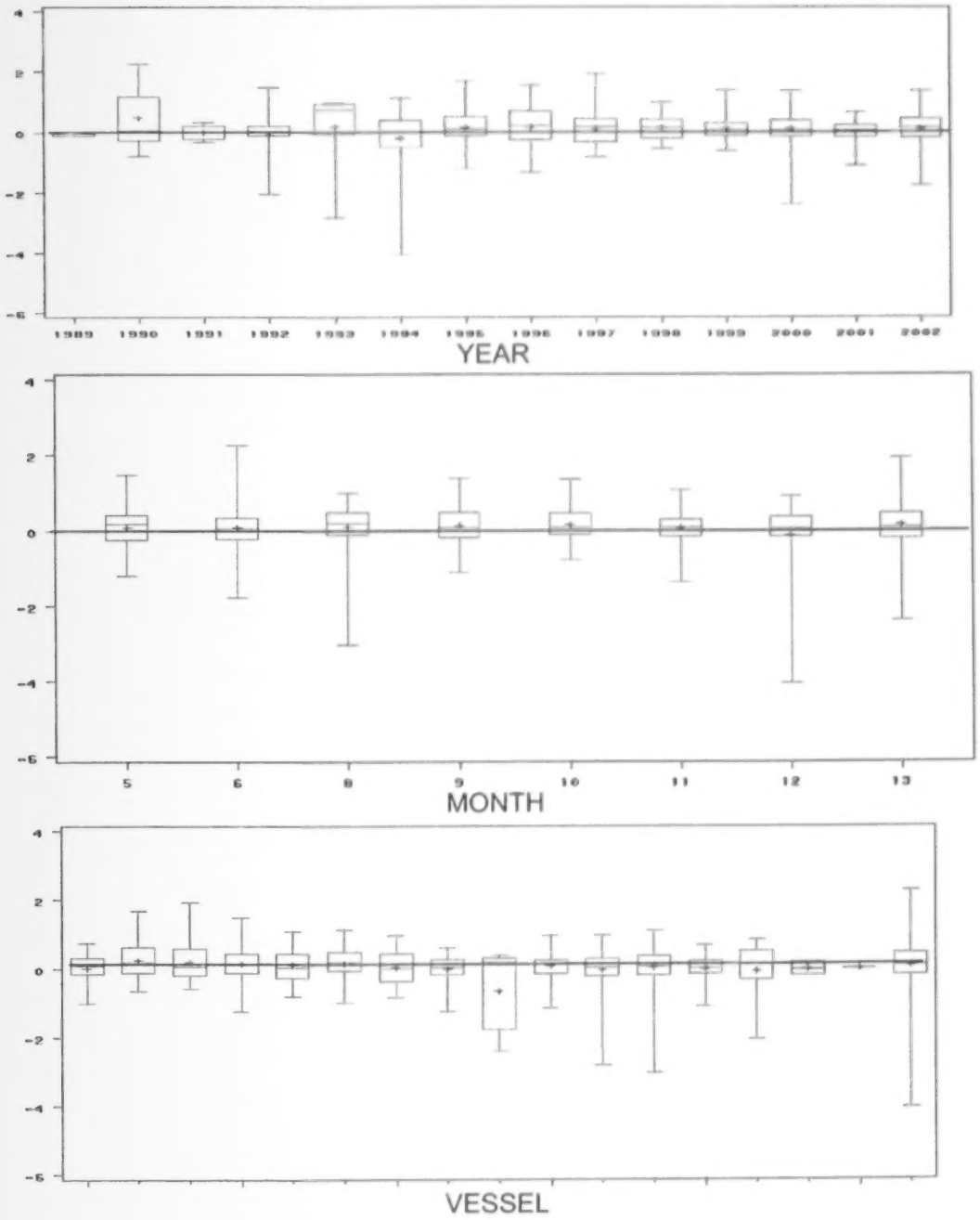


Figure 21. Standardized large vessel (>500 t) shrimp catch in number per hour (000's) in Div 2G (SFA 4), 1993 – 2002. Solid line = males; broken line = females.

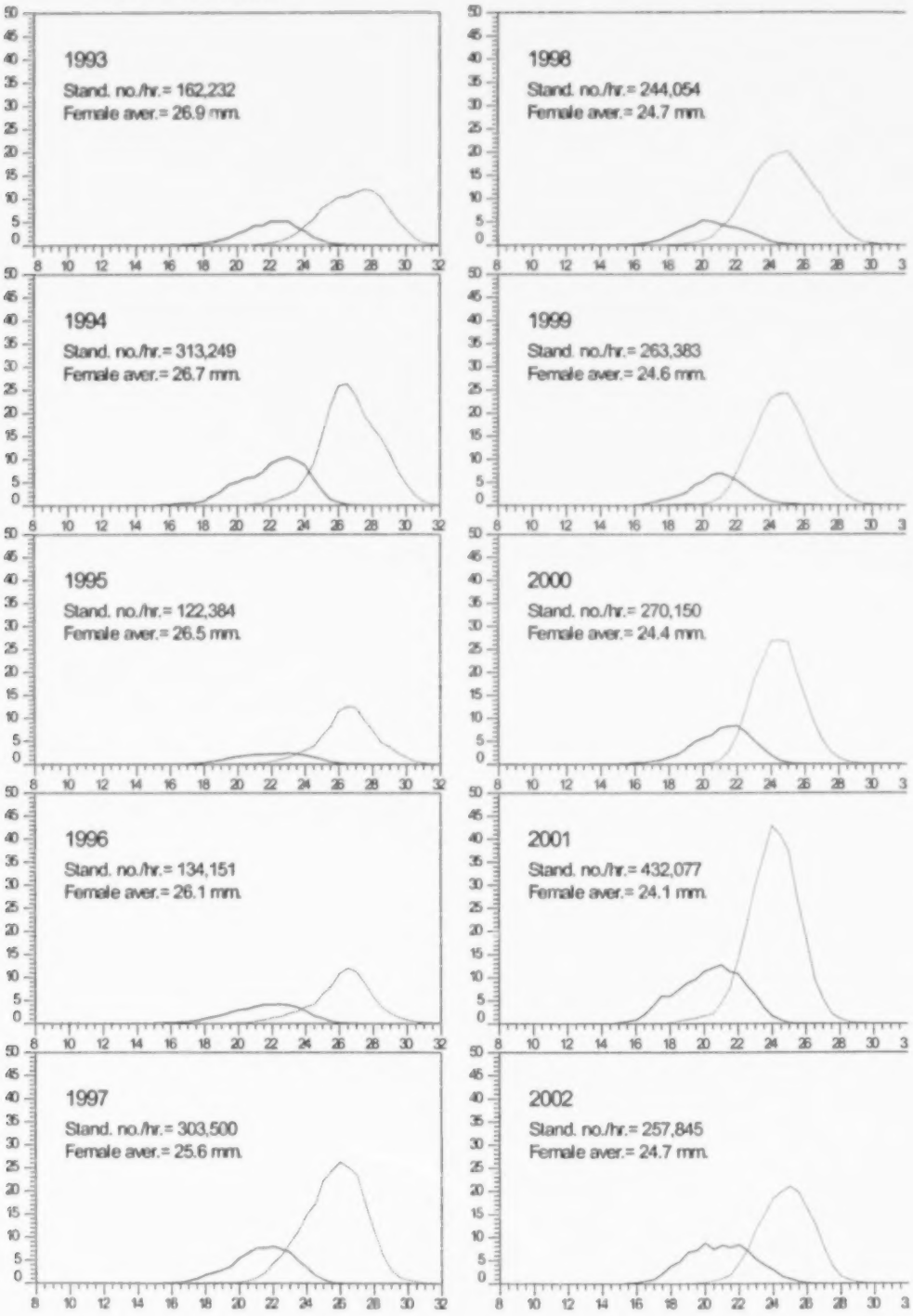


Figure 22. Distribution of large vessel (>500 t) shrimp catches in Div. 0B (SFA 2), 1990 – 2002. (Observer data aggregated into 10 min. squares).

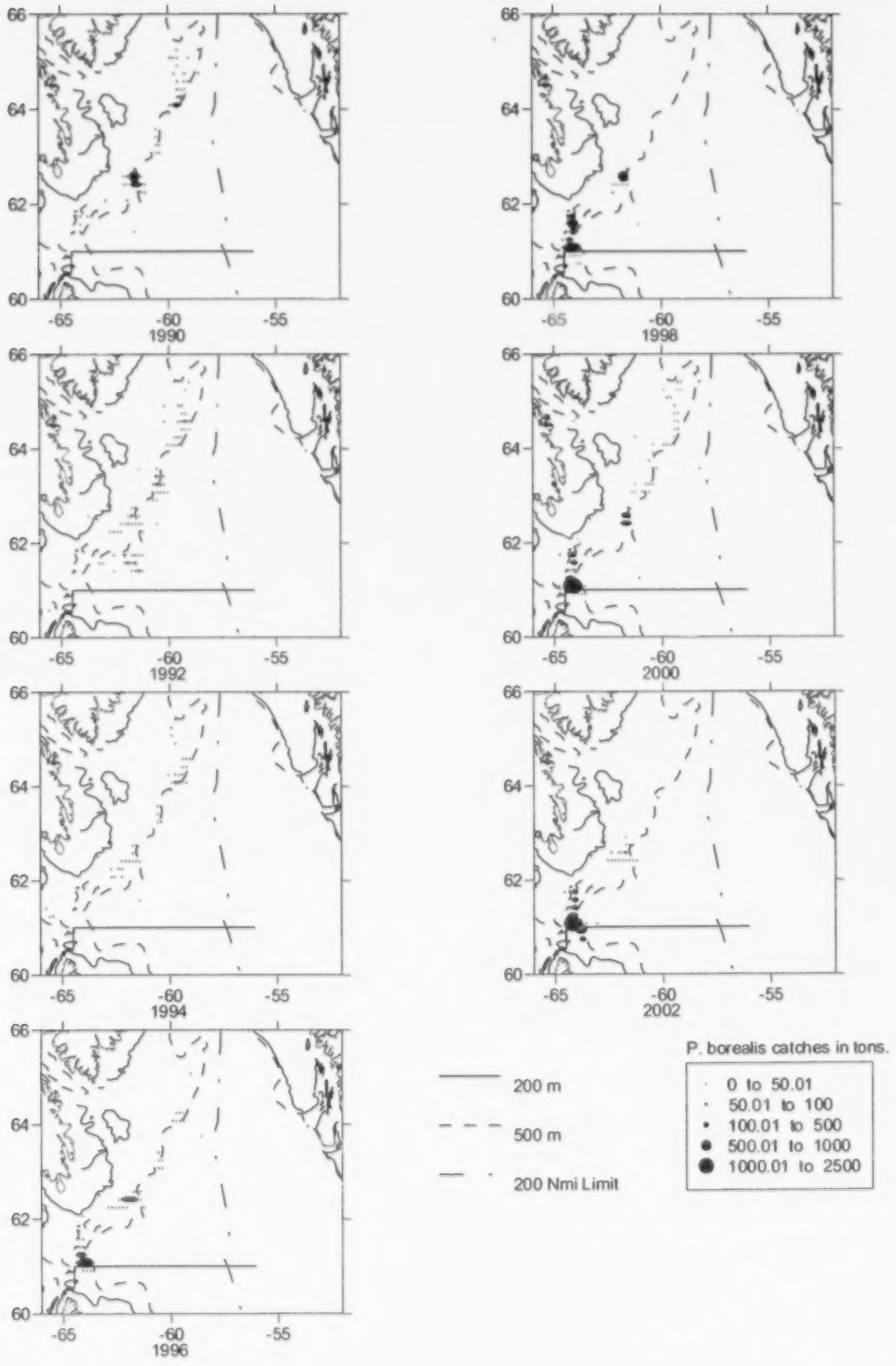


Figure 23. Seasonal distribution of large vessel (>500 t) shrimp catches (tons) in Div. 0B (SFA 2) during 2002. (Observer data aggregated into 10 min. squares.)

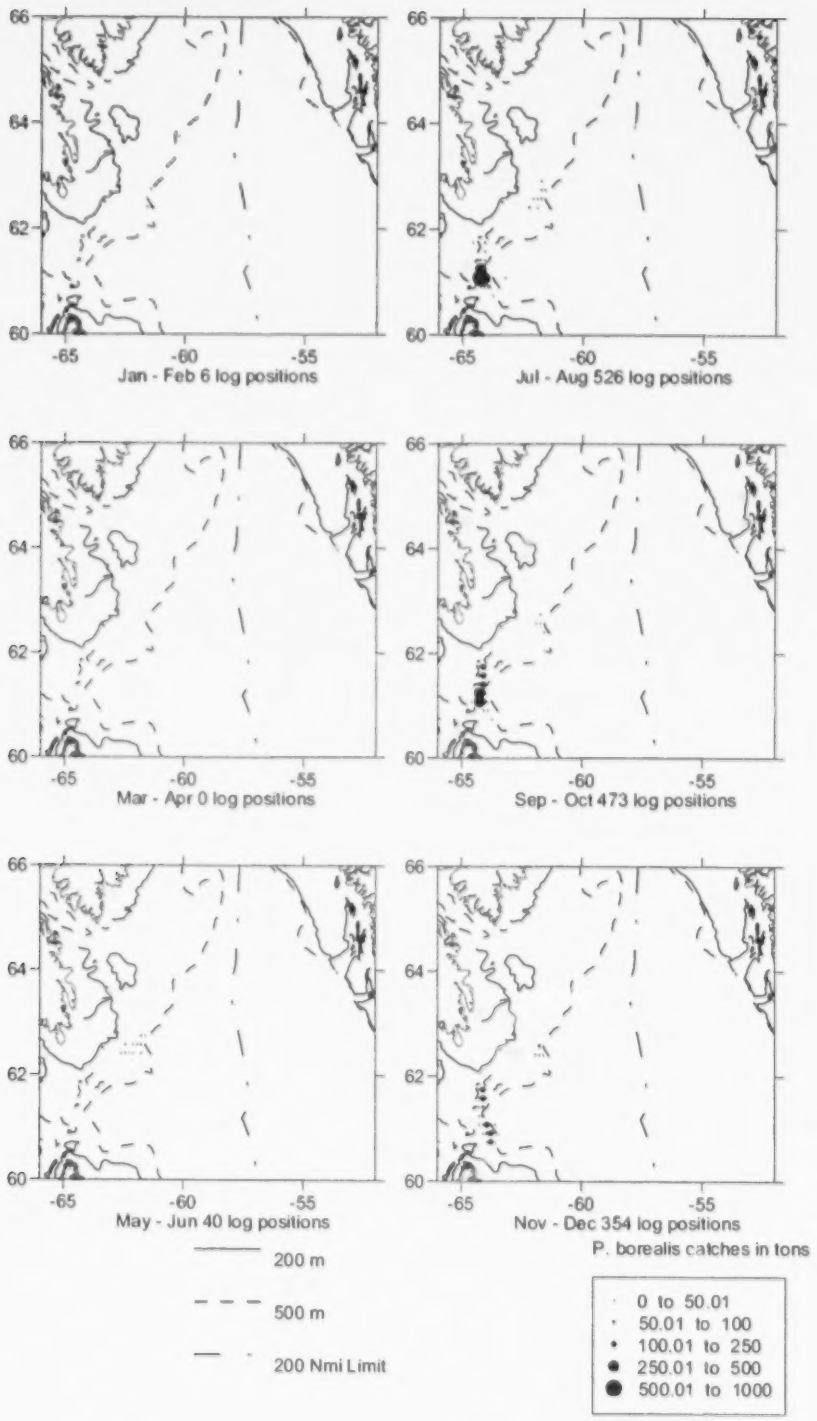


Figure 24. The distribution of residuals around estimated values for various parameters used in the Catch Per Unit Effort (CPUE) model developed for large vessels fishing in Div 0B (SFA 2), 1989 – 2002.

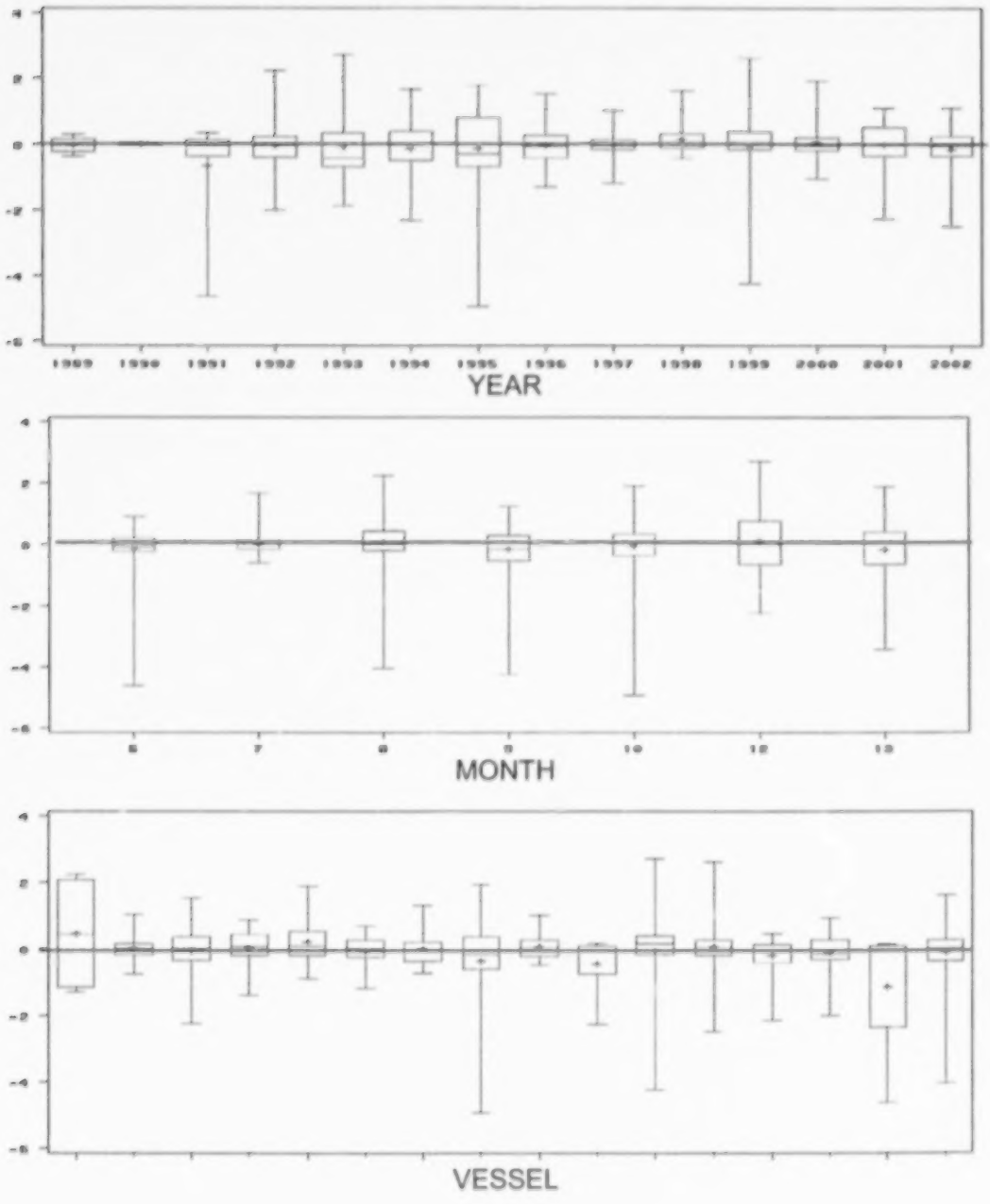


Figure 25. Standardized large vessel (>500 t) shrimp catch in number per hour (000's) in Div 0B (SFA 2), 1993 – 2002. Solid line = males; broken line = females.